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HYGIENIC LABORATORY.—BULLETIN No. 18.

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September, 1904.

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Biological
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Serials

An account of the Tapeworms of the genus *Hymenolepis* parasitic in man,

INCLUDING

Reports of several new cases of the Dwarf Tapeworm (*H. nana*) in the United States.

BY

BRAYTON H. RANSOM.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1904.

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AN ACCOUNT OF THE TAPEWORMS OF THE GENUS HYMENOLEPIS PARASITIC IN MAN, INCLUDING REPORTS OF SEVERAL NEW CASES OF THE DWARF TAPEWORM (HYMENOLEPIS NANA), IN THE UNITED STATES.

(Prepared under the direction of CH. WARDELL STILES, Chief of Division of Zoology.)

By BRAYTON H. RANSOM, M. A.,[a]
Assistant in Division of Zoology, Hygienic Laboratory, United States Public Health and Marine-Hospital Service.

SUMMARY.

The present paper comprises a full account, from both zoological and medical standpoints, of the representatives, three in number, of the tapeworm genus *Hymenolepis,* parasitic in man. This genus has received but slight attention from American authors. Recent indications, however, point to the probability that one species of this genus, *Hymenolepis nana,* the dwarf tapeworm of man and rats is, compared with other tapeworms, not an uncommon parasite of man in this country. Owing to its small size, and the necessity of depending for a diagnosis of its presence upon the discovery of its eggs in the feces by microscopical examination, it is undoubtedly frequently overlooked. About 100 cases altogether of this parasite have been reported from man.[b] Eleven cases have been found in this country during 1902–1903—in Texas, Georgia, South Carolina, and the District of Columbia.

The tapeworm in question was first described, upon the basis of specimens from rats, in 1845, by Dujardin, as *Tænia murina* [not Gmelin, 1790]; it was first noticed in man by Bilharz at Cairo, Egypt, in 1851, and a description under the name of *Tænia nana* was published by Siebold (1852). The earlier name, *T. murina,* had already been used for another form by Gmelin in 1790, and the name *nana* is accordingly retained as the correct specific designation.

It has been proved experimentally by Italian investigators that when eggs of this parasite are swallowed by white rats, the embryos hatch, bore into the intestinal

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[a] Transferred June 1, 1903, to U. S. Bureau of Animal Industry, as Assistant Zoologist.

[b] Since the manuscript of this paper was finished, six more cases have been found by this laboratory in the District of Columbia, among 123 children in orphan asylums. Several probable cases have been reported to us by letter by Dr. J. B. De Velling, Jackson, Miss. Dr. L. E. Magnenat, of Amarillo, Tex., has found four cases in a single family (Stiles, 1903c). Finally Dr. H. M. Hallock (1904a), of the U. S. Army, has reported two cases at Fort Porter, Buffalo, N. Y., in soldiers recently returned from the Philippines. This makes altogether for the United States something over 25 cases, all but one having been recorded since August, 1902, and 16 of which have been found by members of this laboratory in a systematic examination for intestinal parasites of about 3,500 persons. It is significant that in these examinations only two cases of the beef-measle tapeworm, *Tænia saginata,* and none of the pork-measle

villi, become transformed into an intermediate stage (cercocysts), and later fall again into the lumen of the intestine to become adult. It is presumed that a similar development occurs in man, although the possibility remains that development, both in man and in the rat, may also occur by means of some intermediate host, such as an insect, not yet determined.

From the clinical side abstracts of 106 cases are given. Five of these are here reported for the first time.

Most of the cases have been in males and the large majority in children, commonly between the ages of 5 and 10 years.

Thirty-eight of the cases were found in the inmates of orphan asylums, a poorhouse, and an insane asylum, and more cases have been reported from cities than from rural districts. Children in bad hygienic surroundings seem especially liable to infection, and institutional life seems to favor the occurrence of the dwarf tapeworm, both in children and in adults.

The prevalence of infection has been estimated as 10 per cent among the children of Italy. In the Government Hospital for the Insane, Washington, the parasite has been found in 0.3 per cent of about 2,000 patients examined. In about 160 fecal examinations recently made by Stiles (1903a) in the Southern States, the percentage of occurrence of *H. nana* was 0.25 per cent.

The largest number of cases from one State or country, 65, has been reported from Italy; the District of Columbia ranks second with 6 cases. The geographical distribution of the parasite as recorded for man accords very well with the distribution of the parasite as recorded for rats, and is practically cosmopolitan like that of its hosts.

The part of the intestine infected is the ileum.

The number of worms present in any one case varies from a single specimen to several thousand.

Simultaneous infection with other parasites is common. As many as four other species of parasites have been found occurring with *H. nana*.

Infection may persist from 2 months to 2½ years, perhaps to 5 years, and longer, or until terminated by successful treatment.

Comparison with statistics relative to larger tapeworms indicates that the symptoms produced by the presence of *H. nana*, while not more severe, apparently occur with greater frequency in a severe form in cases of *H. nana* than in cases of the larger tapeworms. This circumstance, however, is considered not to indicate a greater nocuity of the smaller worm; it is simply due to the fact that a relatively greater number of cases are overlooked.

The symptoms produced by the dwarf tapeworm are usually slight, and may be absent entirely, even though the worm be present in large numbers. Severe symptoms, however, such as persistent diarrhea, epileptiform attacks, etc., occasionally occur. The most frequent symptoms are abdominal pain, with or without diarrhea; convulsions of various sorts, frequently epileptiform; headache and strabismus. Nasal and anal pruritus, common in cases of infection with other tapeworms, are

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tapeworm, *Tænia solium*, were found. These facts continue not only to bear out the original assumption of Doctor Stiles that the dwarf tapeworm is going to prove a common American parasite, but seem to indicate, furthermore, the likelihood that it will turn out to be the most common of the tapeworms parasitic in man in this country.

In October and December, 1902, the examination of 60 children 1 to 15 years old, at a hospital in Buenos Aires, Argentina, showed 11 cases of infection with *H. nana*. (Lynch, 1904.) On a prior occasion 101 children were examined and no cases were found. Lynch considers the results of these examinations to indicate that the parasite is becoming more common in Argentina, and suggests the likelihood of many cases having been introduced by Italian immigrants, large numbers of whom have come into the country in recent years.

rarely seen with *H. nana*. A predisposition to nervous disease seems to be the important factor in the appearance of nervous symptoms.

The local pathological changes seem to be slight. The elimination of a toxin which is absorbed by the host possibly plays an important part in the production of morbose phenomena.

Diagnosis rests upon the discovery of eggs in the feces.

Treatment is with male fern and several repetitions are frequently necessary.

Prophylaxis consists in everything which will avoid the entrance of the eggs of the parasite into the mouth, as well as of insects, some of which may be able to serve as intermediate hosts and thus convey infection. It comprises the destruction of rats and mice; the protection of food from contamination by the excreta of rats; the exclusion of insects from the food; and general carefulness in regard to what is put into the mouth; especially should this last rule be enforced in the case of children, who commonly put into their mouths all sorts of objects, some of which, soiled by the excreta of infected persons or rats, may carry the eggs.

Hymenolepis diminuta, the flavopunctate tapeworm of man and of rats, was first described by Rudolphi, in 1819, from specimens collected in Brazil from rats. The same species was redescribed by Creplin (1825a) as *Tænia leptocephala*. It was first described from man by Weinland (1858), who did not recognize its identity and called it *Hymenolepis flavopunctata*.

Development occurs by means of an intermediate host, and several insects have been shown to act in this rôle; the common meal moth (*Asopia farinalis*), both in larval and adult stages, is perhaps the usual intermediate host.

Twelve cases have been reported from man, 3 in the United States, 2 in South America, and the rest in Europe.

Symptoms were practically absent in all the cases.

Diagnosis is established by the discovery of the eggs in the feces.

The worm seems to be easily expelled, and may pass without treatment. A simple cathartic has been efficient.

Prophylaxis consists in avoiding the ingestion of any of the various insects which may act as intermediate hosts.

Hymenolepis lanceolata, the lanceolate tapeworm of geese and ducks, has been recorded but once from man.

INTRODUCTION.

Of the tapeworms parasitic in man there is one genus which is commonly overlooked in medical text-books, or at most passed over with only the slightest mention, namely, *Hymenolepis*. This genus, composed of a considerable number of species, is mostly restricted in its hosts to insectivorous mammals and birds, but three species, *Hymenolepis nana*, *H. diminuta*, and *H. lanceolata* have been also reported from man. The first of these, *H. nana*, is the most common of the three, and the most important. Like the larger tapeworms it is frequently the cause of severe symptoms, and indeed has been alleged by some authors to be productive of more serious effects than the former. In Italy, particularly Sicily, it seems to be one of the commonest parasites; some authors estimate that as many as 10 per cent of the children of certain classes in that country are infested by it. Its existence in the United States has been practically ignored on account of its apparent rarity, only 1 case until recently having been reported for this country. There is, however, some evidence to show that *H. nana* is considerably more common in the United States than generally supposed.

Owing to the small size of the tapeworm in question and the consequent necessity of depending for a diagnosis of its presence upon the discovery of its eggs in the feces, it seems very probable that it has been overlooked many times; and it is expected that as the microscope comes more generally into use as an aid in diagnosis of diseases, new cases of *H. nana* will come to light from time to time. Weight is given to these statements by the fact within the past year 11 new cases have been added to the single one formerly on record for the United States; namely, 1 in Texas by Dr. John T. Moore, 1 in South Carolina and 3 in Georgia by Dr. Ch. Wardell Stiles, and 6 in the District of Columbia by members of this laboratory.[a]

In the light of these recent developments *Hymenolepis nana* appears to merit more attention than it has hitherto received in this country, and Doctor Stiles has accordingly requested me to prepare a paper upon the genus *Hymenolepis*, taking into consideration such species as are of interest in human medicine. A paper similar to the present also seemed desirable from another standpoint; most of the literature is not generally accessible, being scattered in various foreign journals and in several languages; although Blanchard in 1891 published in French an excellent paper on the genus, which contained a complete résumé of the literature then extant, practically nothing has appeared in English, and altogether there is very little upon the group readily available to the American physician. In the preparation of this paper, practically the entire literature of *Hymenolepis* in man has been consulted, with the intention of bringing together everything that is known to date, regarding this genus in its relation to human medicine.

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[a] For additional cases see footnote, p. 7.

Genus HYMENOLEPIS[a] Weinland, 1858.

GENERIC DIAGNOSIS.—Family Tæniidæ, subfamily Dipylidiinæ: Head generally small; rostellum retractile, well developed and armed, or rudimentary and unarmed; suckers usually unarmed. Genital pores, single, marginal, unilateral. Testes few; usually three in each segment. Uterus sac-like; often filling the segment; frequently with outpocketings and incomplete partitions. Eggs with two, three or four membranes, the inner of which closely invests the embryo and may exhibit a small mamillate projection at each pole; the outer membrane is separated from the inner by a wide intervening space. Larva a cercocyst or staphylocyst.

TYPE SPECIES.—*Hymenolepis flavopunctata* Weinland, 1858=*H. diminuta* (Rudolphi, 1819).

The genus *Hymenolepis* was established by Weinland in 1858 with *H. flavopunctata* (= *H. diminuta*) as type, but was neglected almost entirely until rehabilitated by Blanchard in 1891. The characters of the genus as it now stands cover 30 or 40 species, some of which in many respects are widely divergent. It is therefore likely that in the course of time some of these species will be taken out of the genus and placed in new genera. Cohn (1899 c, e, g, 1900 b, 1901 b) has recently taken a step in this direction by proposing a division of the genus into two subgenera. In the subgenus *Hymenolepis* he would place those forms of the group which possess either an unarmed and rudimentary rostellum, or a rostellum armed with 20 to 30 hooks. In the second subgenus *Drepanidotænia* he would place forms possessing 8 to 10 hooks. According to this classification, *H. diminuta* and *H. nana* fall together in the first subgenus, and *H. lanceolata* in the second. There are, however, certain objections to this scheme of classification, one being that it is decidedly artificial and as such has been opposed by Wolffhügel (1899b, 1900 b) and also by myself in a former paper (Ransom, 1902). As an indication of the artificial nature of the proposed classification, it may be remarked that there are, in the group, tapeworms with 8 to 10 hooks which resemble, in the greater part of their anatomy, worms with rudimentary rostellum much more than they resemble other worms with 8 to 10 hooks; consequently, the use of a character, based upon the number of hooks, as a criterion in classification would often result in placing in one subgenus a species which, in all essentials except this one character, resembled the species typical of the second subgenus, more than it resembled the type of the first, and vice versa.

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[a] SYNONYMS.—*Hymenolepis* Weinland, 1858; *Diplacanthus* Weinland, 1858 (not Agassiz, 1842, fish); *Lepidotrias* Weinland, 1858; "*Hymenolepsis*" of Osler, 1895, and other authors (misprint); "*Diplocanthus*" of Cohn, 1899 (misprint).

Although the plea of utility is an argument which might be advanced in favor of Cohn's division of the genus, it is, in fact, about the only argument, and moreover of little weight, since it is questionable whether such a division offers any advantages, even when viewed from a purely practical standpoint. While the character selected by Cohn as a distinguishing mark is certainly an easy one to use (though the loss of hooks from the rostellum might in some cases prove misleading), it does not seem to me that anything is to be gained by the separation of the various species now comprising the genus into the purely artificial groups proposed by Cohn, when it is almost certain that a revision will sooner or later be necessary, which will break up the genus along altogether different lines.

As there seems to be no sufficient reason, either from theoretical or practical considerations, for recognizing Cohn's division into subgenera, and as an attempt to revise the genus upon a rational basis is beyond the purposes of the present paper, if indeed such a revision could successfully be carried out at the present time, the three forms to be discussed will be regarded simply as belonging to the same genus, *Hymenolepis*, and the differences between them as of specific value only.

KEY FOR THE DETERMINATION OF THE SPECIES OF *HYMENOLEPIS* PARASITIC IN MAN.

Strobila small, 5 to 45 mm. long, by 0.5 to 0.9 mm. wide, filiform; head armed with a crown of 20 to 30 hooks; eggs generally oval, with filaments attached to the poles of the inner membrane; common .... *Hymenolepis nana.*

Strobila 10 to 60 mm. long by 2.5 to 4 mm. wide; head unarmed; eggs generally round, prominent intermediate layer of albuminous substance between outer and inner membranes, outer membrane frequently with radial striations; rare .... *Hymenolepis diminuta.*

Strobila lanceolate, 30 to 130 mm. long by 5 to 18 mm. broad; head small, compared with strobila, armed with 8 to 10 hooks; eggs oval, without filaments on the inner membrane; very rare .... *Hymenolepis lanceolata.*

The Dwarf Tapeworm—HYMENOLEPIS NANA[a] **(Siebold, 1852) Blanchard, 1891.**

Specific diagnosis.—*Hymenolepis:* Strobila 5 to 45 mm. in length, and 0.5 to 0.9 mm. in maximum breadth, composed of about 100 to 200 segments. Head subglobular, 130 to 480 μ in diameter; rostellum well developed, freely movable, armed with a single crown of 20 to 30 hooks, 14 to 18 μ in length; suckers globular, 80 to 150 μ in diameter. Neck long. Anterior segments very short; following segments increase in length and breadth, but remain broader than long, except that the length of the hindermost segments may occasionally equal or even slightly exceed

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[a] Synonyms.—*Tænia murina* Dujardin, 1845 (not *T. murina* Gmelin, 1790=*Cysticercus fasciolaris* Rudolphi); *Tænia nana* Siebold, 1852 (not Van Beneden, 1858); *T. ægyptiaca* Bilharz, 1852 (not Krabbe, 1869); *Diplacanthus nanus* (Siebold) Weinland, 1858; *T.* (*Hymenolepis*) *nana* Siebold of Leuckart, 1863; *T.* "*rana*" of Bell, 1886 (misprint); *Hymenolepis nana* Blanchard, 1891; *H. murina* Blanchard, 1891; "*Hymenolepsis*" *nana* of Osler, 1895, and other authors (misprint); *Tænia* "*minima*" of Huber, 1896 (misprint for *T. murina*).

their breadth. Genital pores on the left margin, near anterior border of each segment. Three testes in each segment; vas deferens enlarged to form a seminal vesicle within the cirrus pouch, while a seminal reservoir outside cirrus pouch is only slightly developed or absent. Gravid uterus occupies nearly the entire segment; wall of uterus with a few inconspicuous infoldings, forming incomplete partitions extending into the cavity of the uterus. Eggs number 80 to 180 in each segment; oval or globular; two distinct membranes; outer membrane 30 to 60 μ in diameter; inner membrane 16 to 34 μ in diameter, presenting at each pole a more or less conspicuous mamillate projection, provided with filamentous appendages; embryonal hooks 10 to 14 μ long.

Habitat.—Small intestine of brown or Norway rat (*Mus decumanus*); black rat (*Mus rattus*); dwarf field mouse (*Mus minutus*); house mouse (*Mus musculus*); garden dormouse (*Eliomys quercinus*); and man (*Homo sapiens*).

Development.—The embryo is swallowed, and after hatching enters a villus of the small intestine, where it transforms into a cercocystis, which in turn falls into the lumen of the intestine and becomes adult.

Geographic distribution.—Egypt, England, Italy, Sicily, Russia, Germany, Servia, France, Austria, Denmark, Siam, Japan, Pennsylvania, District of Columbia, Maryland, South Carolina, Georgia, Texas, Brazil, Argentina.

The Flavopunctate Tapeworm—HYMENOLEPIS DIMINUTA[a] (Rudolphi, 1819) Blanchard, 1891.

Specific diagnosis.—*Hymenolepis:* Strobila 10 to 60 mm. in length, 2.5 to 4 mm. in maximum breadth; composed of 800 to 1,300 segments. Head small, almost globular; 200 to 600 μ in width; rostellum rudimentary, pyriform, only slightly protractile; hooks absent; suckers globular, near the apical portion of the head, 80 to 160 μ in diameter. Neck usually short. Segments throughout strobila broader than long. Genital pores on left margin, near the junction of the anterior and middle thirds of each segment. Three testes in each segment; vas deferens dilates into a prominent seminal vesicle before entering the cirrus pouch, within which also is a vesicle. Gravid uterus occupies most of the proglottis; its cavity is subdivided into a large number of incompletely separated compartments filled with eggs. Eggs round or slightly oval; outer membrane 54 to 86 μ in diameter, yellowish in color, may be radially striated; inner membrane 24 by 20 μ to 40 by 35 μ in diameter, with mamillate projection at each pole often not apparent; between outer and inner membranes a prominent third layer of albuminous substance, often appearing as two delicate smooth membranes, with intervening space filled by a granular coagulum; embryonal hooks 11 to 16 μ in length.

Habitat.—Adults in small intestine of brown or Norway rat (*Mus decumanus*); black rat (*M. rattus*); house mouse (*M. musculus*); Egyptian or roof rat (*M. rattus alexandrinus*); wood or field mouse (*M. sylvaticus*); *Rhipidomys pyrrhorhinus* [according to Linstow, 1878 a, p. 23]; and man (*Homo sapiens*).

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[a] Synonyms.—*Tænia diminuta* Rudolphi, 1819; *T. leptocephala* Creplin, 1825; *Hymenolepis flavopunctata* Weinland, 1858; *Taenia* (*Hymenolepis*) *flavopunctata* Weinland, 1859; *H.* (*Lepidotrias*) *flavopunctata* Weinland, 1861; *T. flavomaculata* Leuckart, 1863; *T.* "*flavopuncta*" Weinland of Cobbold, 1864 (misprint); *T.* "*flaviopunctata*" of Vogt, 1878 (misprint); *T.* "*flavopunktata*" of Stein, 1882 (misprint); *T. varesina* E. Parona, 1884; *T. minima* Grassi, 1886; *T.* "*septocephala*" of Perroncito & Airoldi, 1888 (misprint); *Hymenolepis diminuta* (Rudolphi, 1819) Blanchard, 1891; "*Hymenolepsis*" *flavopunctata* of Osler, 1895, and other authors (misprint); *T.* "*varerina*" Parona of Huber, 1896 (misprint for *T. varesina*); *T.* "*flavapunctata* of Simon, 1896 (misprint); *T.* "*leptocefala*" Previtera, 1900 (misprint); *T. ceptocephala* Lussana & Romaro [?date] (misprint); "*Tenia flavopunctata*" of Packard, 1900.

Development.—The larval stage (*Cercocystis H. diminutæ*) occurs in larval and adult meal moths (*Asopia farinalis*); in young and adult earwigs (*Anisolabis annulipes*); and in adult beetles (*Acis spinosa* and *Scaurus striatus*).

Geographic distribution.—Massachusetts, Pennsylvania, Nebraska, Iowa, District of Columbia, Maryland, Brazil, Italy, Germany, France, Austria.

The Lanceolate Tapeworm—HYMENOLEPIS LANCEOLATA[a] (Bloch, 1782) Weinland, 1858.

Specific diagnosis.—*Hymenolepis:* Strobila lanceolate, 30 to 130 mm. long, by 5 to 18 mm. broad. Head compared with strobila very small; rostellum protractile, armed with single row of 8 hooks, 31 to 35 μ long. Neck short, often retracted with head into anterior portion of strobila. Segments much broader than long throughout the strobila. Genital pores on right-hand margin of segment near anterior border. Three testes in each segment; vas deferens enlarged to form a seminal vesicle, frequently S-shaped, before entering cirrus pouch; within latter, a second vesicle; vas deferens describes a complete loop in cirrus pouch before being transformed into the cirrus; cirrus freely protrusible, armed with spines. Female organs on opposite side of segment from genital pore; gravid uterus sac-like, with out-pocketings, filling most of the segment. Egg oval or spherical, with two thin membranes separated by an intervening space containing a small amount of albuminous substance; inner membrane occasionally with polar papillæ; outer membrane 50 by 35 μ to 100 by 100 μ in diameter; inner membrane 30 by 25 μ to 40 by 25 μ in diameter; embryonal hooks 8 to 15 μ in length.

Habitat.—Adults in intestine of tame duck (*Anas boschas domestica*); black duck (*Anas obscura*); tame goose (*Anser anser domesticus*); muscovy duck (*Cairina moschata*); white-headed duck (*Erismatura leucocephala*); pochard (*Aythya ferina*); African teal (*Aythya nyroca*); red-crested pochard (*Aythya rufina*); flamingo (*Phœnicopterus roseus*). Zschokke (1902) has recently reported one case in man (*Homo sapiens*).

Development.—Not experimentally determined. Larval stage probably lives in small fresh-water crustacea.

Geographic distribution.—England, Denmark, France, Germany, and Austria.

The Dwarf Tapeworm—HYMENOLEPIS NANA (Siebold, 1852) Blanchard, 1891.

HISTORICAL REVIEW.

Hymenolepis nana was first discovered in man by Bilharz in 1851 at Cairo, Egypt, and the next year Siebold (1852) published a description, based upon letters from the discoverer, which translated reads as follows:

Tænia nana Sieb.[b]—It will not surprise us that among the many helminths which are found in man in the Nile countries there is also a special tapeworm. Bilharz discovered such a one and wished to call it after its native country, *Tænia ægyptiaca;*

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[a] Synonyms.—*Tænia anserum* Frisch, 1727 [according to Rudolphi, 1810]; *T. anseris* Bloch, 1779 [according to Rudolphi, 1810]; *T. lanceolata* Bloch, 1782 (not *T. lanceolata* Chabert; not *T. lanceolata* Rosseter, 1891); *T. acutissima* Pallas, 1781, in part; *T. lanceola* Batsch, 1786; *Halysis lanceolata* (Bloch, 1782) Zeder, 1803; *Hymenolepis* (*Dilepis*) *lanceolata* (Bloch, 1782) Weinland, 1858; *Drepanidotænia lanceolata* (Bloch, 1782) Railliet, 1892; *Hymenolepis* (*Drepanidotænia*) *lanceolata* Cohn, 1899; *Tænia-Drepanidotænia lanceolata* (Bloch) Dadai, 1900.

[b] *Tænia nana* Sieb.—Es wird uns nicht überraschen, dass unter den vielen Helminthen, welche in den Nilländern den Menschen bewohnen, sich auch ein besonderer Bandwurm befindet; Bilharz hat einen solchen entdeckt und nach seinem Vaterlande

but, as it might develop later that the distribution of this parasite is not confined merely to Egypt, I have proposed for it the name of *Tænia nana*, as this tapeworm, through its smallness, contrasts extraordinarily with the other two tapeworms of man. That this small tapeworm is not perchance a torn or mutilated fragment may be asserted definitely, as I found many individuals uninjured and provided with a rounded last segment.

The first report upon this parasite I received from Bilharz, under date of May 1, 1851, in the following words:

"In the body of a boy who had died of meningitis there appeared after the first cut into the intestine a countless number of small tapeworms, *Tæniæ*, with broad segments completely formed, of the thickness of sewing thread, and hardly 10‴ long. The head is large, its anterior surface smooth, quadrangular, and its corners formed by the round suckers located upon spherical eminences. In the posterior portion the head gradually grows narrower and tapers into the long slender neck. The segments found in succession behind the neck become gradually broader, until at the posterior end of the body they assume a breadth 3–4 times that of the head. This *Tænia*, moreover, occupied only a limited portion of the ileum."

Tænia ægyptiaca benennen wollen, da es sich aber später herausstellen könnte, dass die Verbreitung dieses Parasiten sich nicht bloss auf Aegypten beschränkt, so habe ich für denselben den Namen *Tænia nana* vorgeschlagen, indem dieser Bandwurm gegen die beiden anderen Bandwurmarten des Menschen durch seine Kleinheit ausserordentlich absticht. Dass dieser kleine Bandwurm nicht etwa ein abgerissenes oder verstümmeltes Bruchstück ist, lässt sich mit Bestimmtheit behaupten, da ich viele Individuen unverletzt und mit abgerundetem letzten Gliede versehen vorfand.

Die erste Nachricht über diesen Schmarotzer erhielt ich von Bilharz unterm 1. Mai 1851 mit folgenden Worten:

"In der Leiche eines an Meningitis verstorbenen Knaben zeigte sich mir nach dem ersten Schnitt in den Darm eine unzählige Menge eines kleinen Bandwurmes, einer *Tænia* mit breiten Gliedern, vollständig ausgebildet, von Nähfadendicke und einer Länge von kaum 10‴. Der Kopf ist gross, seine Vorderfläche eben, viereckig, die Ecken durch die runden, auf kugeligen Erhabenheiten stehenden Saugnäpfe gebildet. Nach hinten nimmt der Kopf allmälig an Breite ab und geht in den langen schmalen Hals über; die hinter dem Halse sich nach und nach einfindenden Glieder werden immer breiter, bis sie am Hinterende des Körpers die 3–4 fache Breite des Kopfes einnehmen. Diese *Tænia* nahm übrigens nur eine beschränkte Strecke des Ileum ein."

Unterm 1. December schrieb mir Bilharz über diesen Bandwurm weiter:

"*Tænia nana* ist gewiss ein ausgewachsenes Thier. Ich habe die Eier am frischen Thier, das ich leider seit jenem Male nie wieder fand, beobachtet und auch in Weingeistexemplaren wieder erkannt. Sie sind kugelrund, haben eine dicke gelbliche Schale, und zwar nur eine, wie mir scheint, doch zog sich der Inhalt der Eier unter dem Einfluss des Weingeistes kugelförmig zusammen, es mag daher noch eine dünne Dotterhaut vorhanden sein. Die sechs Häkchen der Taenien-Embryonen waren in den frischen Eiern deutlich zu sehen. Die Cirri finde ich, wie Sie es bereits bemerkt haben, alle auf einer und derselben Seite angebracht. Die Eier sind 1 00‴ [sic] gross."

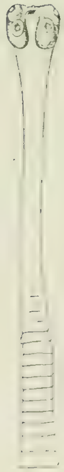
Als Diagnose für diesen Bandwurm stellte Bilharz folgende Beschreibung hin:

Tænia nana.—Corpus filiforme, depressum, caput antice obstusum [sic], collum versus sensim attenuatum, acetabulis subglobosis rostello pyriformi uncinulorum bifidorum corona armato. Articuli transversi, cirri omnes unum eundemque marginem spectantes. Ovula globosa testa lævi simplici instructa.

Long. 6 lin.

Patria Ægyptus, in hominis intestino tenui semel reperta permagno.

Under date of December 1 Bilharz wrote me further with regard to this tapeworm: "*Tænia nana* is certainly a full-grown animal. I observed the eggs in the fresh animal, which, unfortunately, I never have found again since that time, and also recognized them again in samples in alcohol. They are round like balls, have a thick yellowish shell, and indeed only one, as it appears to me; yet the contents of the eggs contract under the influence of the alcohol into a globular shape, hence there may be present also a thin yolk membrane. The six little hooks of the *Tænia* embryos were to be seen distinctly in the fresh eggs. I find the cirri, as you already have observed, all placed on one and the same side. The eggs are $\frac{1}{100}'''$ in size."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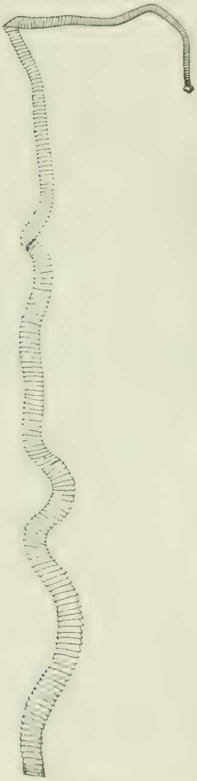
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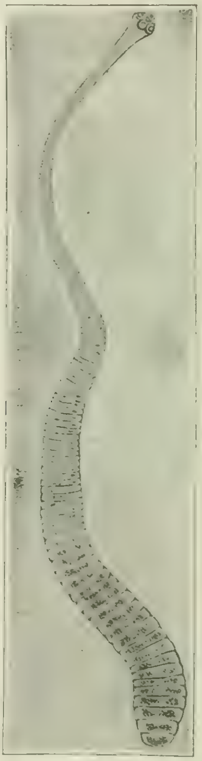
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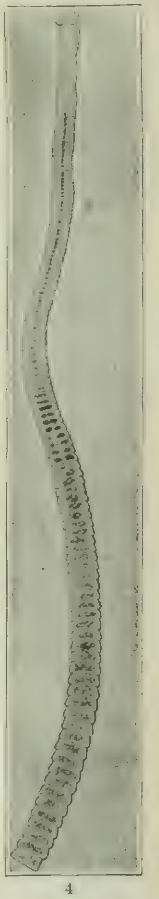
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FIG. 1.—Original type figure of *Tænia nana* Siebold (=*H. nana*). Head and portion of strobila. Enlarged. (After Siebold, 1852, fig. 18.)

FIG. 2.—Original type figure of *Tænia murina* Dujardin (=*H. nana*). Head and portion of strobila. Enlarged. (After Dujardin, 1845a, pl. 12, fig. A1.)

FIG. 3.—Head and strobila of *H. nana*. Enlarged. (After Leuckart, 1863, p. 393, fig. 112.)

FIG. 4.—Head and portion of strobila of *H. nana*. Enlarged. (After Railliet, 1893, p. 293, fig. 190).

As a diagnosis for this tapeworm, Bilharz offered the following description:

Tænia nana: Body filiform, depressed; head obtuse anteriorly, gradually tapering into the neck, with almost globular suckers and pyriform rostellum armed with a crown of bifid hooks. Segments broader than long, cirri situated all on one and same margin. Eggs globose, furnished with a single thin shell. Length, 6 lines.

Native country, Egypt; collected once in large numbers from the small intestine of man. (Translation).

Leuckart (1863) added to this brief account by a study of some of the original specimens, and more recently our knowledge of the anatomy has been further increased by Blanchard (1886a, e, f, 1891a), Grassi & Calandruccio (1887a), Mertens (1892), and a number of other observers.

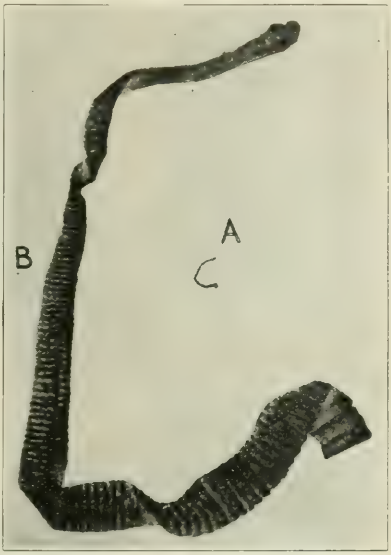

FIG. 5.—Head and strobila of *H. nana*. A, natural size; B, enlarged. (After Stein, 1882, pl. 12, figs. 9–10.

Some years earlier than the first report of *Hymenolepis nana* in man, Dujardin (1845a, pp. 564–565, pl. 12, fig. A) reported from the rat, *Mus decumanus*, a new tapeworm, *Tænia murina* (not *Tænia murina* Gmelin, 1790 = *Cysticercus fasciolaris* Rudolphi, 1810), which seems in all respects to be identical with *Hymenolepis nana*, and is so considered by Grassi, Lutz (1894), Mingazzini (1898), Massari (1898), and others. The following is a translation of Dujardin's description:

Tænia murina Dujardin, *nov. sp.*[a]—Twenty-five mm. long, from 0.55 mm. to 0.9 mm. broad, composed of very numerous segments, four to eight times as broad as they are long; head 0.32 mm. broad, with a short thick rostellum surrounded by a simple crown of twenty to twenty-four hooks from 0.015 mm. to 0.017 mm. long; suckers 0.08 mm. broad; neck 0.15 mm. broad; first segments very short; the following (male) 0.07 mm. long, from 0.55 mm. to 0.6 mm. broad; the last filled with ripe eggs from

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[a] Ténia murin (*Tænia murina* Duj., *nov. sp.*).—Long de 25 mm., large de 0 mm. 55 à 0 mm. 9, formé d'articles très nombreux, quatre à huit fois aussi larges que longs; tête large de 0 mm. 32, avec une trompe courte, épaisse, entourée d'une couronne simple de vingt à vingt-quatre crochets longs de 0 mm. 015 à 0 mm. 017; ventouses larges de 0 mm. 08; cou large de 0 mm. 15; premiers articles très courts; les suivants (mâles) longs de 0 mm. 07, larges de 0 mm. 55 à 0 mm. 6; les derniers remplis d'œufs murs longs de 0 mm. 15 à 0 mm. 17, larges de 0 mm. 8 à 0 mm. 9; tous les articles ayant leurs angles postérieurs un peu saillants, aigus, en dents de scie; orifices génitaux unilatéraux; testicule claviforme, étendu transversalement depuis le milieu jusqu'au réceptacle du pénis en forme de cornue; pénis lisse, très grêle, peu saillant; œufs elliptiques à trois enveloppes; l'externe longue de 0 mm. 065; la moyenne membraneuse, plissée, longue de 0 mm. 07; l'interne plus résistante, un peu oblongue et terminée par une pointe obtuse à chaque extrémité; embryon long de 0 mm. 029 à 0 mm. 030, avec les crochets de 0 mm. 015 à 0 mm. 016.

Je l'ai trouvé, à Rennes, dans un surmulot (*Mus decumanus*), dans un mulot nain (*Mus pumilus*) [=*M. minutus*], et dans un lérot (*Myoxus nitela*) [=*Eliomys quercinus*].

0.15 mm. to 0.17 mm. long, from 0.8 to 0.9 mm. broad; all the segments having their posterior angles somewhat salient, sharp, shaped like saw teeth; genital orifices unilateral; testicle [misinterpretation of seminal receptacle] claviform, extending transversely from the middle to the receptacle of the penis in the shape of a retort; penis smooth, very slender, not very salient; eggs elliptical with three envelopes; the external one 0.065 mm. long; the middle one membranous, in folds, 0.05 mm. long; the internal one more resistant, somewhat oblong and terminating in an obtuse point at each extremity; embryo from 0.029 mm. to 0.030 mm. long, with hooks from 0.015 mm. to 0.016 mm. long.

I found it at Rennes in a brown rat (*Mus decumanus.*), in a dwarf field mouse (*Mus pumilus*) [=*M. minutus*], and in a garden dormouse (*Myoxus nitela*) [=*Eliomys quercinus*]. (Translation.)

Blanchard (1891a), Moniez (1888), and Linstow (1896a) inclined to the opinion that the two forms *Tænia nana* and *Tænia murina* are distinct species. Blanchard (1896b), however, has more recently come to the conclusion that the slight inconstant differences which have been noted in the two forms are sufficiently accounted for by the difference in habitat, and that the two worms should be united under one species, which he would for reasons of priority call *Hymenolepis murina*. But since the name *Tænia murina* used by Dujardin, is preoccupied, having been applied before 1845 to another form, it can not be retained in this connection. *Tænia nana* Siebold, 1852 being the next available name, the correct designation of the species, placed in its proper genus, is therefore *Hymenolepis nana*.

Linstow (1896a) believed he found differences which would justify a specific distinction between the forms in man and in the rat, but, as Massari (1898) has pointed out, his results are not entirely free from criticism, and his arguments rather unconvincing.

Hymenolepis nana may, accordingly, be regarded as occurring not only in man, but also in the rat, and in the two hosts showing slight and variable differences, brought about by the action upon the parasite of an environment somewhat different in the two cases.

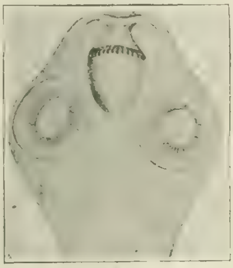
ANATOMICAL DESCRIPTION.

EXTERNAL ANATOMY.

As is well indicated by its name (*nana*, a dwarf) the worm under consideration is characterized preeminently by its small size (fig. 5A). Being also very delicate, and likely to be broken in pieces, it is thus a difficult matter to discover specimens in the feces, unless passed in large numbers.

Strobila. Complete strobilæ with gravid segments may be found ranging in length from 5 or 6 mm. (Blanchard, 1891a) to a maximum, as recorded so far, in man of 35 mm. (Mertens, 1892). In the rat a length as great as 45 mm. has been observed (Stossich, 1898).

Favarcq (1894a) found a worm 75 mm. long, in the intestine of the garden dormouse (*Eliomys quercinus*), which he believed to be a variety of *Hymenolepis murina* (Dujardin). This form possessed hooks somewhat similar to those of *Hymenolepis nana* (= *H. murina*), but as Favarcq made no careful study of its anatomy, not even so far as to determine whether the genital pores were unilateral or alternating, the identity of the form remains doubtful.



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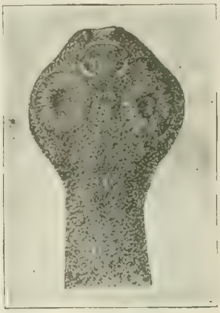

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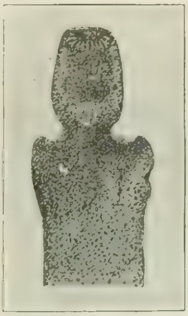

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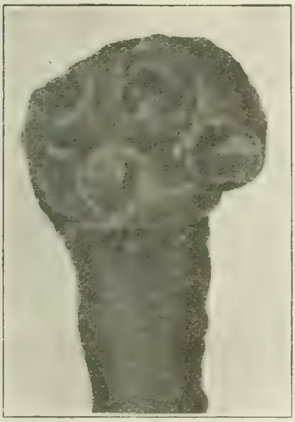

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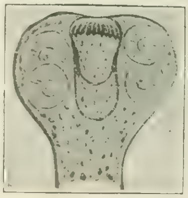

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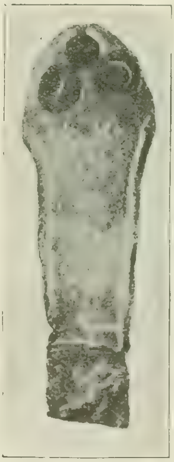

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FIG. 6.—Head of *H. nana*. Enlarged. (After Leuckart, 1863, p. 394, fig. 113.

FIG. 7.—Head of *H. nana*. Enlarged. (After Blanchard, 1886e, p. 328, fig. 3.

FIG. 8.—Head of *H. nana* from which the suckers have been torn away. (After Blanchard, 1886f, p. 333.

FIG. 9.—Head and neck of *H. nana*. Enlarged. (After Miura & Yamazaki, 1897, pl. 14, fig. 1.

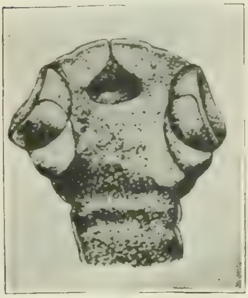
FIG. 10.—Head of *H. nana*. Enlarged. (After Mertens, 1896, fig. 2.)

FIG. 11.—Head and anterior portion of strobila of *H. nana*. Enlarged. (After Stein, 1882, pl. 12, fig. 11.)

Blanchard (1891a) considers 12 to 15 mm. the normal length in man, with a maximum breadth of 0.5 to 0.7 mm. The number of segments ranges from about 110 to 200; in the latter case 40 to 50 of the posterior segments contain fully formed embryos; in the former only the last 8 to 12 segments are gravid. A complete specimen measuring 12.5 mm. possessed 162 segments.

Mertens (1892) found the average length of a number of specimens to be over 20 mm., and the maximum breadth from 0.7 to 0.9 mm. The number of segments varied from 180 to 200, and this character was more or less constant, even with a variation of 3 to 4 mm. in the length.

Miura & Yamazaki (1897) give a length of 20 mm., and a maximum breadth of 0.48 to 0.86 mm., measured in the fresh state, 0.3 to 0.56 mm. after preservation.



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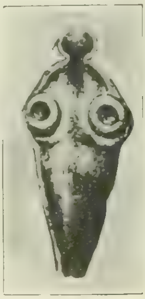

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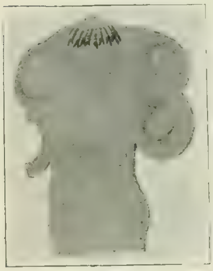

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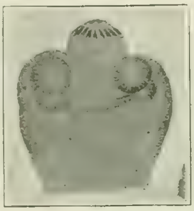

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FIG. 12.—Head of *H. nana*. Enlarged. (After Krantz from Küchenmeister & Zürn, [?1881], pl. 5, fig. 2.)

FIG. 13.—Head of *H. nana* with protracted rostellum. Enlarged. (After Krantz from Küchenmeister & Zürn, [?1881], pl. 5, fig. 3.)

FIG. 14.—Head of *Tænia murina* Dujardin (= *H. nana*). Enlarged. Original type figure. (After Dujardin, 1845a, pl. 12, fig. A3.)

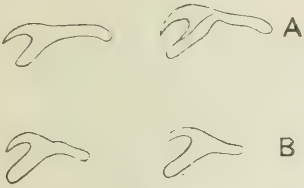
FIG. 15.—Head of *T. murina* Duj. (= *H. nana*) with protracted rostellum. Enlarged. Original type figure. (After Dujardin, 1845a, pl. 12, fig. A2.)

Dujardin (1845a) gives a length of 25 mm., and a maximum breadth of 0.55 to 0.9 mm., from specimens from rats; Grassi & Calandruccio (1887a), a length of 33 to 40 mm.; according to Linstow (1896a), incomplete specimens measured 23 mm., with a maximum breadth of 0.82 mm.

Head.—The head (figs. 1, 6–15) is more or less globular, flattened dorso-ventrally, and when viewed in front is somewhat rectangular, with its suckers at the four rounded angles. Its size has been given by various observers from 215 to 480 μ in width and 360 to 450 μ in length. It is often difficult, however, to tell where the head ends and the neck begins, especially in certain states of contraction, so that it is not always possible to determine the length with any degree of accuracy. Examples from the rat give measurements falling within the limits noted above. In specimens both from man and from the rat, measured in this laboratory, the head has ranged in width from 130 to 250 μ.

Suckers.—The suckers, globular in shape, measure from 90 to 150 μ (Mertens, 1892). In specimens from the rat they seem to be generally smaller—according to Dujardin (1845a) 80 μ, and after Linstow (1896a), 79 μ, in diameter, while we have seen them here, in sizes from 70 to 90 μ, measured after preservation. In the live worm they are very protractile, and may be extruded to a considerable distance (Grassi & Calandruccio, 1887a). When thus extruded they may be torn away and give rise to an anomaly (fig. 8) first described by Blanchard (1886f), and also noticed by Grassi & Calandruccio (1887a).

Rostellum.—Besides suckers the head possesses another organ of attachment, namely a protractile and freely movable rostellum (figs. 6, 7, 9–15), armed with hooks. In preserved material the rostellum is usually found retracted, but in material which has been fixed while still living, or in the live worm itself, is often seen extruded.



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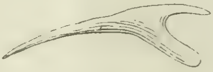

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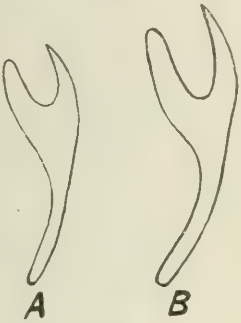

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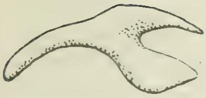

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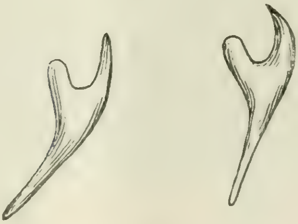

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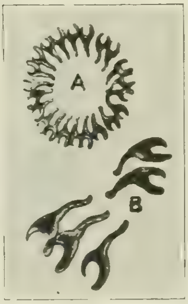

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FIG. 16.—A. Hooks of *T. murina* Dujardin (= *H. nana*) from rat (*Mus decumanus*). Enlarged. (After Krabbe 1865, pl. 3, figs. 56–57.) B. Same from mouse (*Mus musculus*). Enlarged. (After Krabbe, 1865, pl. 3, figs. 58–59.)

FIG. 17.—Hook of *H. nana*. Enlarged. (After Leuckart, 1886a, p. 996, fig. 409B.)

FIG. 18.—Hooks of *H. nana*. A, from man; B. from the rat. (After Linstow, 1896a, figs. iii and 3.)

FIG. 19.—Hook of *H. nana*. Enlarged. (After Railliet, 1893, p. 294, fig. 191.

FIG. 20.—Hooks of *H. nana*. Enlarged. (After Mertens, 1892, fig. 3)

FIG. 21.—Hooks of *H. nana*. A, complete crown; B, isolated hooks. Enlarged. (After Krantz from Küchenmeister & Zürn, [?1881], pl. 5, fig. 4.)

Hooks.—The hooks (figs. 16–21) are arranged in a single row around the anterior part of the protrusible portion of the rostellum. Their number seems to be rather variable, with a range, putting together the numerous recorded observations, of 20 to 30. Leuckart (1863) gives 22 to 24 and (1886a, p. 997) 24 to 28; Rasch (1894) 22; Miura & Yamazaki (1897) 23; Zograf (1893) 23 to 28; Grassi & Calandruccio (1887a) 24 to 28; Linstow (1896a) 24; Moniez (1888), in eight specimens, found seven with 24 to 26 hooks, one with 30; Blanchard (1891a) gives 24 to 28 as the normal number. All of these observations were made upon specimens from man, while specimens from the rat, according to Dujardin (1845a) and Krabbe (1865) possess 20 to 24; Linstow (1896a) finds 23 to 24. The hooks possess a rather long, somewhat curved dorsal root, directed forward on the rostellum, and, directed backward, a thick, heavy ventral root which is about equal in length to the sharp pointed prong, forming with it a sort of fork.

The roots of the hooks are more or less deeply embedded in the surface of the rostellum, and according to Mingazzini (1899) possess their own musculature, namely, fibers which are found in the inner sac of the rostellum.

The size of the hooks has been given as 14 to 18 μ. Krabbe (1865) gives the size in worms from the rat and mouse as 10 to 13 μ, but no other observer has found them so small. Linstow (1896a) would draw a distinction between the hooks of the worms as found in man and in the rat, but comparisons made in this laboratory of forms from both hosts show them identical both in shape and size.

Neck.—The neck (fig. 11) usually is slender, and somewhat less in diameter than the head, but this character varies with the state of contraction. Its width may be defined by the limits 80 and 300 μ, and its length to the first appearance of segmentation, 80 μ and 1 mm. or more.

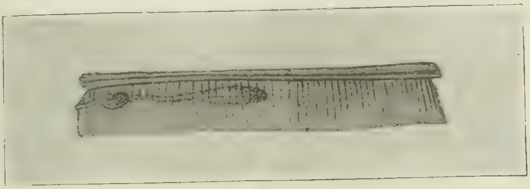
Segments.—As usual in tapeworms, segmentation is at first very indistinct. The segments are broader than long, and trapezoidal. The posterior border of each segment thus projects laterally beyond the anterior border of the following segment, making the edge of the strobila serrate. The younger segments are 6 to 10 times broader than long, a ratio which decreases toward the posterior end. Occasionally some of the posterior segments are seen stretched out so that their length exceeds their breadth. The width of the strobila gradually increases toward the posterior end, at or near which it reaches the maximum size already given. The last few segments may gradually decrease in width, and in a complete worm the last one is rounded off (figs. 3, 30).

Genital pore.—The genital pores (figs. 22–24, 28, 31–33) are located toward the anterior border of the segments, one in each segment, and all upon the left side, except as occasionally one is found upon the right side.

INTERNAL ANATOMY.

As in all cestodes, the spaces among the various organs are filled with a connective tissue known as *parenchyma*. *Calcareous corpuscles*, often large and present in great numbers amid the parenchymatous tissue of tapeworms, are comparatively small and few in *H. nana*.

Rostellum.—The rostellum is a sac-like body embedded in the axial portion of the head between the four suckers. Its wall is formed by a membrane which is continuous with the cuticula at the anterior surface of the head. The protrusible portion is occupied by a second smaller sac likewise limited by a membrane. Upon retraction the anterior part of the rostellum containing the inner sac is drawn



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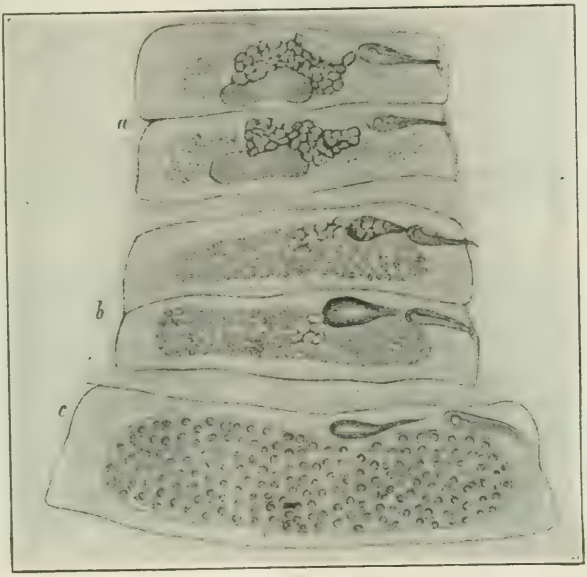

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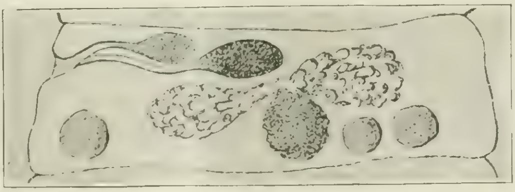

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Fig. 22.—Proglottid of *T. murina* Duj. (= *H. nana*). Enlarged. Copy of original type figure. (After Dujardin, 1845a, pl. 12, fig. A5.)

Fig. 23.—Proglottids of *H. nana*: *a*, showing ovary; *b*, containing eggs in course of formation; *c*, gravid. (After Leuckart, 1863, p. 396, fig. 114.)

Fig. 24.—Proglottid of *H. nana* showing reproductive organs. Enlarged. (After Leuckart, 1886a, fig. 409A.)

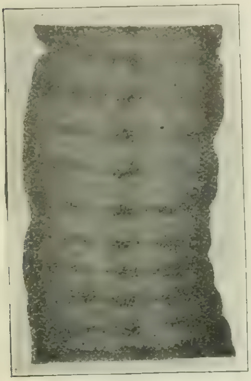
backward into the posterior part by the action of muscle fibers which extend longitudinally between the inner surface of the outer sac and the base of the inner sac. The anterior part of the rostellum is thus telescoped, so to speak, into the posterior part (fig. 10). Both the outer and the inner sac are filled by a loose parenchymatous tissue; they are each supplied with longitudinal and circular fibers in immediate relation with their walls, besides numerous longitudinal fibers extending through the parenchyma. Zograf (1893) considers the mass of the rostellum to be made up of fibers running in a spiral direction. Mingazzini (1899) does not find any circular fibers, but considers longitudinal fibers only to be present, the relations of which are changed in different states of protraction or retraction of the rostellum so that they sometimes present the appearance of circular or spiral fibers. Numerous muscle fibers also extend in various directions from the outer sac through the head. The size and relative dimensions of the rostellum are, naturally, somewhat variable. Leuckart (1886a, p. 997) gives its size as 100 μ long by 88 μ wide. According to Blanchard (1891a) it measures 100 μ long by 80 to 95 μ wide. Miura & Yamazaki (1897) find it 56 μ long, and Mertens (1892) gives its size in the retracted state as 130 to 140 μ long by 80 μ wide. Measurements made in this laboratory of two specimens, in one of which the rostellum was protruded, in the other retracted, are as follows: First specimen, protruded portion of rostellum, 48 μ long by 60 μ wide; remainder of rostellum 100 μ long by 80 μ wide. Second specimen, rostellum, 124 μ long by 60 μ wide; protrusible portion, 50 μ long by 40 μ wide.

NERVOUS SYSTEM.—Two main lateral *longitudinal nerves*, one on either side, may be distinguished running through the entire strobila and united in the scolex by a ganglionic commissure posterior of the rostellum. As Mingazzini (1899) noticed, there are sometimes apparent in the posterior third of the rostellum two masses of cells, one on either side. These cells are evidently *nerve cells* and are similar to those found in the same situation in *H. diminuta* and *H. carioca* (Zschokke, 1889; Ransom, 1902). The position of the lateral nerves in the segment is the usual one among the Tæniidæ, namely, a short distance laterad from the excretory vessels (*m. l. n.*, figs. 32, 33).

MUSCULAR SYSTEM.—The muscular system is only weakly developed. Beneath the cuticula lie the usual *subcuticular muscular fibers*, an *outer circular* and an *inner longitudinal* layer.

The main part of the muscular system consists of a layer of *longitudinal fibers* lying in the parenchyma, not far removed from the cuticula and separating the segment into a central and a cortical portion.

Linstow (1896a) maintains that in *Hymenolepis nana* from man (fig. 32) the cortical portion is, in respect to the thickness of the segment, relatively much thicker than in the form from the rat (fig. 33), which is one of his reasons for viewing the forms as distinct species. This character, however, is very inconstant, and varies with the manner of preservation of the material, and with the age and state of contraction of the segments. The layer of longitudinal fibers is to be regarded as derived in part from the longitudinal subcuticular muscle fibers of the scolex and neck, in the manner described by Lühe (1894, 1896) for *Anoplocephala perfoliata* and other forms, also for *Hymenolepis carioca* (see Ransom, 1902). Longitudinal fibers, which in these regions form part of the subcuticular muscle system, as they pass backward, sink inward away from the cuticula, increase in size



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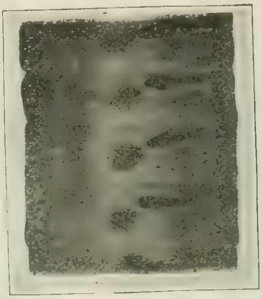

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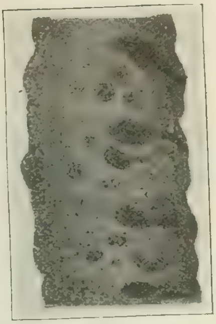

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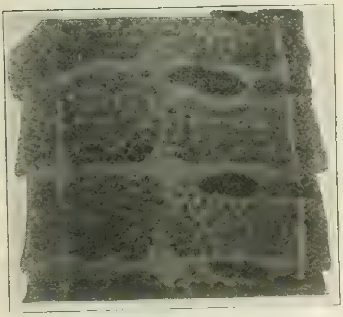

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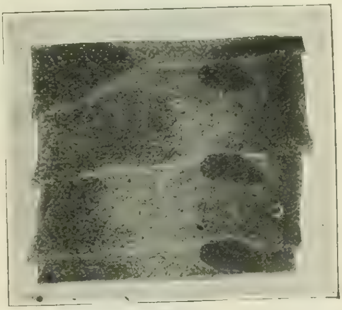

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FIG. 25.—Portion of strobila of *H. nana*, 1 mm. behind head; drawn with camera lucida from fresh material. Showing formation of segments begun, and primordia of reproductive organs. Enlarged. (After Miura & Yamazaki, 1897, pl. 14, fig. 2.)

FIG. 26.—Proglottids of *H. nana* with cirrus pouch and ovary; drawn with camera lucida from fresh material. Enlarged. (After Miura & Yamazaki, 1897, pl. 14, fig. 3.)

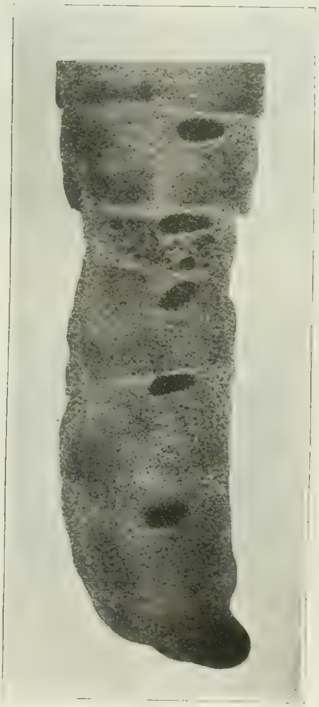
FIG. 27.—Proglottids of *H. nana*, showing cirrus pouch, seminal receptacle, ovary, and testes; drawn with camera lucida from stained preparation. Enlarged. (After Miura & Yamazaki, 1897, pl. 14, fig. 4.)

FIG. 28.—Proglottids of *H. nana*, showing cirrus pouch, seminal receptacle, immature ova, lateral longitudinal excretory canals; camera lucida drawing of stained preparation. Enlarged. (After Miura & Yamazaki, 1897, pl. 14, fig. 5.

FIG. 29.—Gravid proglottids of *H. nana*, with prominent seminal receptacles; camera drawing of fresh material. Enlarged. (After Miura & Yamazaki, 1897, pl. 14, fig. 6.)

and in their new position make up the mass of the longitudinal muscle layer. *Transverse muscle* fibers, if present, are very few and weakly developed. *Dorso-ventral fibers* are likewise insignificant.

Excretory system.—There are two pairs of lateral longitudinal excretory vessels (figs. 32, 33) which unite in the scolex to form an anastomosis at the base of the rostellum. Two small closed loops extend into the latter, one on either side (Mingazzini, 1899), similar to the loops found in *Hymenolepis diminuta* (p. 88) and *Hymenolepis carioca* (see Ransom, 1902). The ventral vessels are larger than the dorsal throughout the strobila, and are united in the posterior portion of each segment by a transverse vessel.



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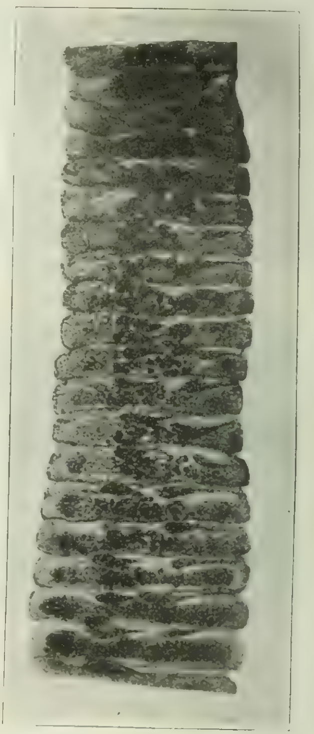

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Fig. 30.—Posterior end of *H. nana* with sterile proglottid (third from top); camera drawing of stained preparation. Enlarged. (After Miura & Yamazaki, 1897, pl. 14, fig. 7.)

Fig. 31.—Portion of strobila of *H. nana*. Enlarged. (After Stein, 1882, pl. 12, fig. 12.)

Reproductive system.—The sexual organs become evident as indistinctly defined masses of cells shortly after the first apparent strobilation (fig. 25). Toward the middle of the worm they are in a state of active sexual maturity. The male organs develop much more rapidly than the female organs, and become active earlier. As is common among tapeworms, they occupy more especially the dorsal part of the segment, while the female organs are more ventral in position.

Male organs.—Three *testes* (figs. 24, 32, 33) are present, the usual number in worms of this genus. They are situated near the dorsal surface, in the posterior portion of the proglottis. When at the height of their development, in the younger segments, they occupy the greater part of the central portion of the parenchyma. Normally two are on the right and one on the left of the median line. This position may be reversed, or rarely only two or as many as four or five may be present, as occurs also in *Hymenolepis diminuta* (p. 89).

Vasa efferentia from the three testes unite to form a *vas deferens* which enters the base of the cirrus pouch. The vas deferens just before reaching the latter is often dilated to form a small *seminal reservoir* (Blanchard, 1891a), as I have also noticed frequently in specimens both from man and from the rat.

The *cirrus pouch* (figs. 22–24, 26–28, 31, *c. p.*, figs. 32, 33) is a club-shaped organ with muscular walls situated near the anterior border of the segment, with its long axis directed transversely, or often somewhat obliquely backward (caudad) toward the genital pore. It lies on the dorsal side of the longitudinal nerve and the excretory canals (figs. 32, 33). Within the cirrus pouch the vas deferens dilates to form a *seminal vesicle*, and then narrows again to form a very slender tube which may be protruded through the genital pore (Leuckart, 1863), or, perhaps, as is common in tapeworms, and as occurs in *Hymenolepis diminuta* (p. 89), protracted into the vagina of the same segment.

Female organs.—The *vagina* (figs. 32, 33) lies on the ventral side of the cirrus pouch, between it and the excretory vessels and longitudinal nerve. It is at first narrow, but mediad from the base of the cirrus pouch, it is swollen into a large oblong *seminal receptacle* (figs. 22–24, 27–33), usually filled in adult segments with a highly refractive hair-like mass of spermatozoa, and for this reason very apparent and prominent. It is easily recognized in any mature segment even under low magnification, lying near the anterior border of the segment, and extending inward toward the median line a variable distance in different segments.

Posterior of the seminal receptacle lies the *ovary* (fig. 24, *ov.*, figs. 32, 33) elongated transversely and bilobed. The egg cells in the ovary measure 10 to 15 μ.

The *yolk gland* (fig. 24, *y. g.*, figs. 32, 33) is an ovoid body situated in the median line, toward the ventral surface of the segment and posterior of the ovary in the space between the backward prolongations of its right and left lobes. The cells of the yolk gland are small, 2 to 4 μ in diameter, strongly eosinophilic.

The so-called *shell gland* (*s. g.*, figs 32, 33) has the usual position between the ovary and yolk gland, on the dorsal side of the latter. It is composed of only a few cells, and is very small and insignificant. It must not be imagined that this tiny complex of a few small cells produces the material out of which the shells of the hundred or more eggs, contained in the gravid segment, are formed, which is a clear impossibility, since a single egg with its fully formed shell is much larger than the entire shell gland. The function of the shell gland in tapeworms in general has never been satisfactorily explained.

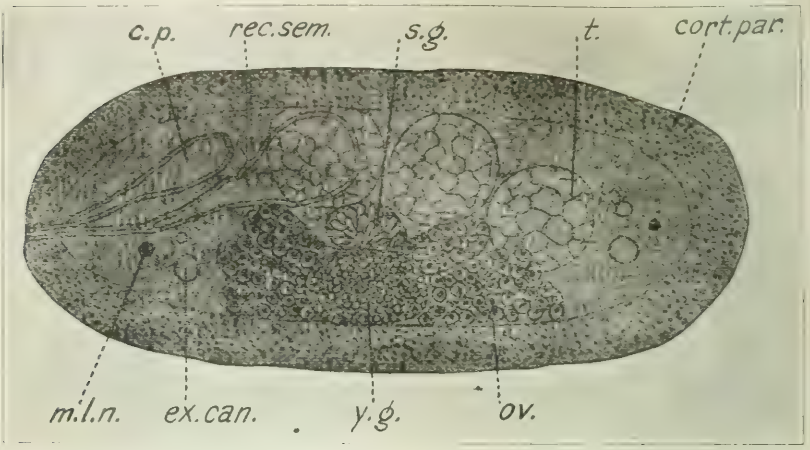


FIG. 32.—Cross section of proglottid of *H. nana* from man: *c. p.*, cirrus pouch; *cort. par.*, cortical parenchyma; *ex. can.*, excretory canal; *m. l. n.*, main lateral nerve; *ov.*, ovary; *rec. sem.*, receptaculum seminis; *s. g.*, shell gland; *t*, testis; *y. g.*, yolk gland. Enlarged. (After Linstow, 1896a, fig. i.)

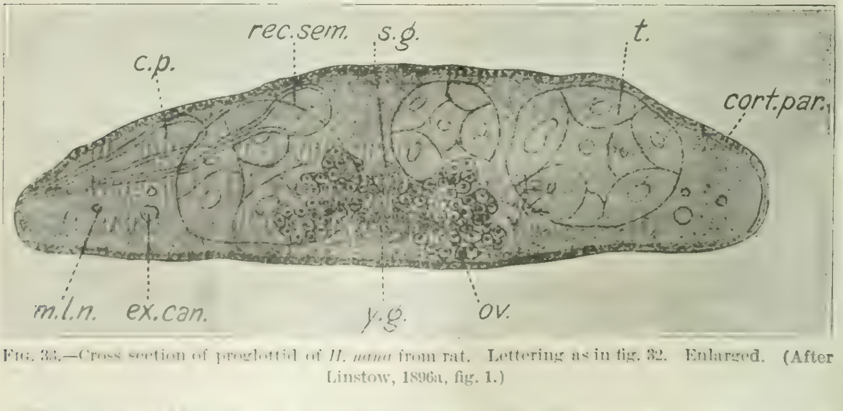
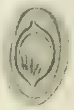


FIG. 33.—Cross section of proglottid of *H. nana* from rat. Lettering as in fig. 32. Enlarged. (After Linstow, 1896a, fig. 1.)

The *uterus* (fig. 23) develops very rapidly after sexual maturity is reached, the ovary disappears, and all the other organs, except the seminal receptacle and the cirrus pouch, degenerate completely or are masked and crowded out of sight by the uterus and its contained embryos. The uterus in the oldest segments occupies practically all of the segment which is thus transformed into a mere egg sac. Blanchard (1891a) was of the opinion that the uterus is not bounded by a membrane, but that the eggs lie scattered throughout the entire parenchyma, so that the segment itself is, as it were, transformed into a uterus. That this idea is inexact, however, is readily apparent when one follows the development of the uterus in well-preserved material.

As in *Hymenolepis carioca* the uterus is at first simply a cellular mass elongated transversely, lying in front of the ovary (Ransom, 1902). This uterine primordium soon hollows out and takes on the appearance of a sac which rapidly fills with eggs and increases in size. Owing to the rapid and continued growth of the uterine wall, more pronounced in some places than in others, and owing to the obstacles by which the free expansion of the uterus is restricted, a modification from the condition of a simple sac-like uterus is brought about, a modification such as occurs in *Hymenolepis carioca*, and to a much greater degree in *H. diminuta* (p. 91). Instead of persisting as a simple sac the fully developed uterus has become a sac with infoldings, tubular processes, or invaginations extending inward among the eggs.



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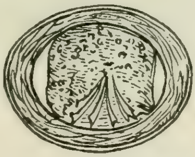

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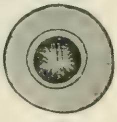

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FIG. 34.—Egg of *T. murina* Duj. (=*H. nana*). Enlarged. Copy of original type figure. (After Dujardin, 1845a, pl. 12, fig. A6.)

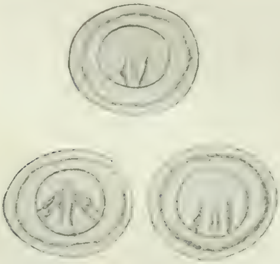
FIG. 35.—Egg of *H. nana*. Enlarged. (After W. H. Ransom, 1856, p. 598, fig. 1.)

FIG. 36.—Egg of *H. nana*. Enlarged. (After Leuckart, 1863, p. 397, fig. 115.)

Eggs.—According to Blanchard (1891a) there are about 100 eggs in each segment; Mertens (1892) states 160 to 180; Leuckart (1886a, pp. 996–997) has counted 80. From the older segments eggs are continually escaping through ruptures in the walls.

Little is known with regard to the development of the eggs, but as first seen in the uterus they do not differ essentially in size (10 to 15 μ) and appearance from eggs which are still in the ovary. A very delicate enveloping membrane may at times be distinguished. The egg begins to segment soon after it enters the uterus, and embryonic development proceeds rapidly. The embryo increases in size and a definite shell is formed.

As found in gravid segments or in the feces the egg (figs. 34–45) is oval, or occasionally spherical. The shell is very clear and transparent, but may take on a slight brownish or yellowish tint after standing for some time in the feces (Grassi, 1887d; Calandruccio, 1890a; Mertens, 1892). It consists of two distinct membranes separated by an intervening space which contains a transparent substance, apparently fluid or semi-fluid and more or less finely granular. The *outer membrane* is very thin, less than 1 μ in thickness. The *inner membrane*, which closely invests the embryo or onchosphere as it is called, has about the same thickness as the outer, but with a more distinct double contour (Mertens, 1892). At two opposite points, usually corresponding to the poles of the egg, the inner membrane has a small *mammillated projection*, often not apparent. To each of these projections are attached a number of clear *hyaline fibers*, resembling elastic fibers in appearance, which pass outward through the intermediate substance toward the outer membrane. Whether there is any constancy in the number of these filaments is not known. Mertens (1892) in observing an egg turned on end, saw at one pole as many as 8, converging like spokes in a wheel and attaching to the papilla of the inner membrane.



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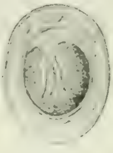

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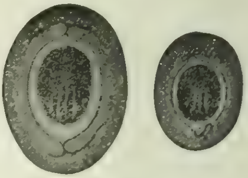

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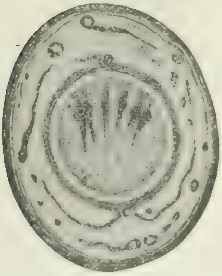

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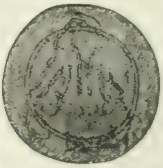

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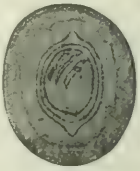

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FIG. 37.—Eggs of *H. nana* from mouse. Enlarged. (After Krabbe, 1865, pl. 7, fig. 108.)
FIG. 38.—Egg of *H. nana* from man. Enlarged. (After Bizzozero, 1889a, pl. 4, fig. g'.)
FIG. 39.—Eggs of *H. nana* from rat. Enlarged. (After Grassi & Rovelli, 1892a, pl. 3, figs. 1 and 2.)
FIG. 40.—Egg of *H. nana*. Enlarged. (After Mertens, 1892, fig. 1.)
FIG. 41.—Egg of *H. nana* from man. Enlarged. (After Linstow, 1896a, fig. iv.)
FIG. 42.—Egg of *H. nana* from rat. Enlarged. (After Linstow, 1896a, fig. 4.)

Beginning at the papillæ the filaments pursue an irregular, winding and convoluted course, gradually becoming more tenuous, but, so far as may be observed, do not branch, and end finally in the peripheral portion of the *intermediate substance* directly underneath the outer membrane. Two layers of slightly different appearance may often be distinguished in this intermediate substance, an inner portion which is clear and homogeneous, free from fibers except where it is penetrated by them in the two polar regions, and a thicker outer portion which is granular and in which the distal ends of the fibers interlace, forming an irregular meshwork. For a great part of their course the fibers frequently follow the boundary between the clear and granular portions of the intermediate substance (Calandruccio, 1890a). According to Mertens (1892) the fibers do not attach to the outer membrane, since this may be split off and the intermediate layer remain undisturbed. The peripheral portion, at least, of the intermediate substance seems thus to possess a certain solidity as though bounded externally by a membrane, which must, however be very thin, separating it from the outer membrane. Mertens (1892), indeed, states that he has observed at times a very thin homogeneous layer between the intermediate substance and the outer membrane, and I have occasionally noted a similar appearance. It frequently happens that the intermediate substance shrinks away from the outer membrane, or from the inner membrane, or from both. This results in the appearance of a third membrane intermediate between the other two, as occurs under similar circumstances in the egg of *H. diminuta*, (p. 93). As in *H. diminuta*, also, there are 3 or 4 comparatively large nuclei (visible in sections) present in the intermediate substance which seem to play a part in the formation of the shell. W. H. Ransom (1856) and Senna (1889) describe a concentric striation of the intermediate substance. Grassi (1886b, 1887d) was the first to observe the filaments which he described as a long convoluted thread apparently attaching to the poles of the inner membrane. Blanchard (1891a) considers that Grassi (1886b, 1887d) and Senna (1889) were in error regarding the presence of filaments, and that they had erroneously interpreted folds or wrinkles of a third membrane. That filaments are present is a well-established fact, however, attested by a number of observers. The three pairs of

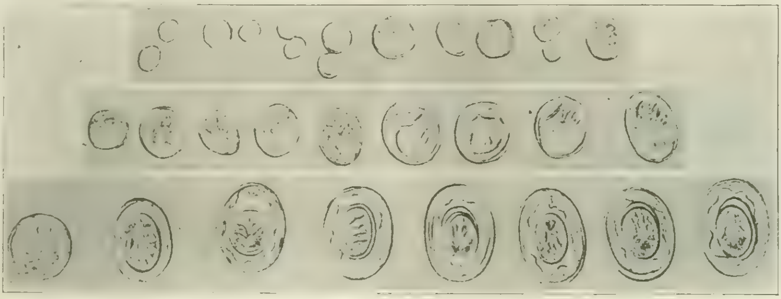

FIG. 43.—Eggs of *H. nana* and spherical bodies, perhaps eggs in course of development. Enlarged. (After Senna, 1889, fig. 2.)

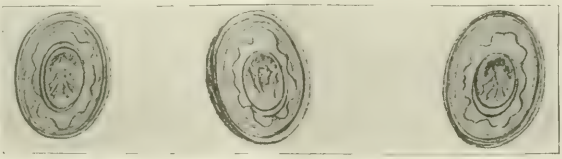

FIG. 44.—Eggs of *H. nana*. Enlarged. (After Senna, 1889, fig. 1.)

hooks with which the onchosphere is supplied are usually found directed toward one pole (Mertens, 1892; Miura & Yamazaki, 1897, and others), and as has been pointed out in other tapeworms (Siebold, 1854; Ransom, 1900), the middle pair differ from the other by being more slender and without a definite ventral root.

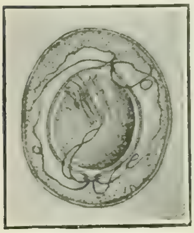
FIG. 45.—Egg of *H. nana*, as seen in fresh feces. Enlarged. (After Ransom, from Stiles, 1903a, p. 85, fig. 85.)

Various *sizes* have been assigned to the eggs, and there is, in fact, considerable actual variation. Bilharz (Siebold, 1852) gives a diameter of 26 μ. Leuckart (1863, 1886a, p. 996) found them 40 to 58 μ. Grassi (1879h), 33 by 33 μ and 33 to 36 by 28 to 31 μ. Grassi & Calandruccio (1887a) 43 by 35 μ to 53 by 40 μ. Perroncito & Airoldi (1888a, b, c), outer membrane, 40 by 32 μ to 52 by 41 μ; inner membrane, 24 by 20 μ to 34 by 24 μ. Mertens (1892), outer membrane, 33 by 39 μ to 45 by 60 μ; inner membrane, 26 by 25 μ to 30 by 29 μ. Senna (1889), 40 by 36 μ to 50 by 40 μ. Linstow (1896a), outer membrane, 39 by 39 μ and 43 by 31 μ; inner membrane, 28 by 28 μ. Blanchard (1891a), outer membrane, 30 to 37 μ by 48 to 55 μ; inner membrane, 16 to 19 μ. According to my own measurements the outer membrane ranges from 36 by 32 μ to 56 by 42 μ; the inner membrane from 18 by 20 μ to 24 by 32 μ. The onchosphere is 5 to 10 μ smaller than the inner membrane. The size of the *embryonal hooks* has been given by various authors from 9 to 16 μ; according to Blanchard (1891a), with whose figures mine agree, they measure 10 to 12 μ. From measurements of 9 eggs, Miura & Yamazaki (1897) give the following figures:

Outer envelope—Length: Maximum, 56.7 μ; minimum, 41.3 μ; mean, 50.7 μ. Breadth: Maximum, 53.2 μ; minimum, 35.1 μ; mean, 42.9 μ.

Inner envelope—Length: Maximum, 32.4 μ; minimum 27 μ; mean, 30.1 μ. Breadth: Maximum, 29.7 μ; minimum, 24.3 μ; mean, 25.9 μ.

Hooks of embryo—Maximum, 13.5 μ; minimum, 10.8 μ; mean, 12.9 μ.

As to the eggs of *Hymenolepis nana* from the rat, which some authors have considered larger than those of the form found in man, it may be said, in the first place, that the size of the eggs is a very variable character as the figures already given testify, and it is consequently doubtful if a satisfactory comparison could be instituted or any constant difference be discovered between the two forms in this regard; and in the second place, considering the great variability of this character, that it would be necessary to make measurements of a large number of examples, with due regard to similarity of conditions, etc., before one affirmed that the eggs were, even generally, larger or smaller in one case than in the other. Dujardin (1845a) gives the size of the egg of *Tænia murina* (= *H. nana*) from the rat as 65 μ; Linstow (1896a), 49 by 42 μ to 54 by 47 μ; measurements which I have made range from 36 by 26 μ to 52 by 36 μ. With the exception of Dujardin's figures these sizes fall within the limits established for *Hymenolepis nana* from man.

Senna (1889) noticed in feces containing completely developed eggs of *Hymenolepis nana*, in six cases, numerous small rounded bodies (fig. 43) measuring from 5 to 10 μ to 30 μ in diameter. The smaller of these were homogeneous in appearance, tinted like mother-of-pearl, and bounded by a very thin membrane, while the larger were more granular and tended to become oval, with a thicker membrane, as indicated by a distinctly double contour. Senna was inclined to interpret these as eggs in course of development, which had prematurely escaped from the uterus, but since he found similar bodies in two cases in which he could not demonstrate the presence of *H. nana*, he was left in doubt with regard to their nature and significance.

DEVELOPMENT AND LIFE HISTORY.

The well known and usual mode of development of tapeworms of the family Tæniidæ, to which *Hymenolepis nana* belongs, is as follows: The *eggs* containing *six-hooked embryos* pass out of the body of the definitive host in the feces. To develop further they must be taken into the alimentary canal of some other animal. If the conditions are suitable in this animal the embryos, after hatching, if this has not already taken place, bore out of the alimentary canal, and, encysted somewhere in the tissues of the body, develop into the intermediate stage, *cysticercus* or *cysticercoid*, as the case may be. When this animal, the intermediate host, is eaten by an animal which can act as a definitive host, the intermediate stage continues its development and becomes transformed into the *adult worm*, which produces eggs, thus completing the cycle. As one would expect, the normal intermediate host is an animal which is the natural food of the definitive host, or otherwise likely to be taken into the alimentary canal of the latter.

Leuckart (1863, pp. 395, 397), upon theoretical grounds, assuming that an interchange of hosts occurred during the life history of *Hymenolepis nana* and noticing the great similarity in the anatomical characters of the worm in question, of certain tapeworms from mice and shrew-mice and of a cysticercoid found by Stein in the meal worm,[a] expressed the opinion that the intermediate stage was developed in some insect.[b]

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[a] Hooks very similar in form are found in the related tapeworms of our mice and shrew-mice, as well as in the cysticercoid of Stein from the meal worm. Translation of Leuckart, 1863, p. 395.

[b] We content ourselves * * * with the supposition that, as in the most nearly related species, the worm passes its youth as a cysticercoid in some insect. (Translation of Leuckart, 1863, p. 397.

The occurrence of the large numbers in which the worm is found in the human intestine he (Leuckart, 1886a; 1886b, p. 661) would explain as resulting from a budding of the cysticercoid in the intermediate host similar to that which takes place in cysticercoids (*Staphylocystis bilarius* and *S. micracanthus*) found by Villot (1878) in certain myriapods. Leuckart (1886a, p. 997) also considered the possibility of some snail being the intermediate host of *H. nana*, upon the basis of information that the children in the vicinity of Belgrade, where a case had been observed in a child (see case No. 6), very commonly ate a kind of little white snail.

Stein's cysticercoid (*Cercocystis tenebrionis* Villot, 1882 = *Cysticercus, tenebrionis* = *Scolex decipiens*) of the meal worm (larva of *Tenebrio molitor*) was considered by Leuckart (1880, pp. 420, 457) the probable intermediate stage of *Tænia murina* Dujardin (= *Hymenolepis nana*). Villot (1882), however, looked upon this cysticercoid as belonging to *Tænia microstoma* Dujardin, 1845, a tapeworm of the mouse, and Moniez (1888) and Linstow (in litt. Moniez, 1888) were of the same opinion.[a] Grassi (1887d) at first believed that this cysticercoid would prove to be the intermediate stage of *Hymenolepis nana*, but later abandoned this hypothesis and concurred (Grassi & Rovelli, 1889b, p. 371) in the opinion of Villot, Moniez, and Linstow.[b]

Grassi and Calandruccio (Grassi, 1887h) attempted numerous times under varying conditions to infest larvæ of *Tenebrio molitor* with eggs of *Hymenolepis nana*, but always without success. They also examined from those localities of Lombardy and Sicily in which they had found *Hymenolepis nana* common in man, hundreds of specimens of numerous species of arthropods, molluscs, and worms, especially edible molluscs, lice, flies, meal worms, the larvæ of certain beetles living in beans, etc., in the hope of finding a cysticercoid to correspond with *H. nana*. All of these investigations resulted negatively with the exception that two cysticercoids were found in a meal worm, which were fed to a man, with negative results. It was during this time that Grassi noticed the great frequency of *Hymenolepis murina* (Dujardin) in rats in Catania, where also from 250 examinations of children, ranging from 4 to 14 years, 20 cases of *H. nana* were found, and noticing the great similarity of the two forms, he was thus led to their identification, as one and the same species, or at most as scarcely distinguishable varieties of a single species. In view of the fact that, although *Hymenolepis nana* was so exceedingly common in these regions, no corresponding cysticercoid was to be found in the many animals examined, belonging to species which *a priori* might be considered possible intermediate hosts, Grassi then resorted to the idea of a direct development; and, indeed, experiments along this line resulted in a demonstration of the fact that the eggs of *Hymenolepis nana* from one rat when fed to another develop into mature worms in the intestine. Development, however, was found not to be direct, i. e., the embryo from the egg did not grow immediately into the form of the adult, but penetrating into a villus developed there into a cysticercoid, which in turn reentered the alimentary canal, to become transformed into the adult stage. The rat was thus shown to act not only as the definitive host, but also as the intermediate host. In spite of the evident exactness of the results of these experiments, and in spite of the probability that the cysticercoid (*Cercocystis tenebrionis*) of the meal worm is more likely the intermediate stage of *Tænia microstoma*, Leuckart (1887) still considered this cysticercoid the intermediate stage in the normal life cycle of *Hymenolepis murina* (= *H. nana*), and looked upon the development of an intermediate stage in the villus of the rat's intestine as unusual, and not of common occurrence in the natural order of things. The balance of evidence, however, seems to indicate that there is no connection between the above-named cysticercoid and *Hymenolepis nana*, but whether the eggs of the latter may not develop into a cysticercoid in some insect, as well as in the intestinal villi of the rat, is not known. So far as the direct evidence goes, however, the development as outlined by Grassi must be considered the normal and usual method.

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[a] It cannot be admitted that the cysticercus of the meal worm belongs to *Tænia nana;* this cysticercus possesses a crown of 30 hooks which have a length of 12 μ, while *T. nana*, as well as *T. murina*, presents only 24 hooks 15 to 18 μ long. In both these characters, on the other hand, the cysticercus of the meal worm corresponds with *Tænia microstoma* of the mouse, with which Villot has already associated it; von Linstow (in litt.) is of the same opinion, with which we can only agree after having examined attentively the head of the cysticercus and that of the adult animal. (Translation of Moniez, 1888.)

[b] The few experiments which Grassi and Rovelli performed, by feeding eggs of *Tænia microstoma* to larvæ of *Tenebrio molitor*, resulted negatively, and this supposed connection between the adult tapeworm and the cysticercoid in question is still not definitely established. (Grassi & Rovelli, 1892a, p. 78.)

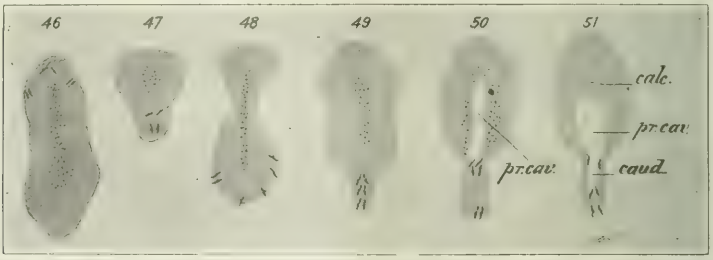
The experiments by which the life history was determined are as follows (Grassi, 1887h; Grassi & Rovelli, 1892a):

Thirty-four white rats were used, aged from 1 to 3 months, kept in clean cages, closed, except on one side, which was covered with wire screen. After weaning, the rats were fed only with bread and pure water. The mothers were determined to be free from tapeworm, during lactation by examination of the feces, and afterwards by killing and examining post mortem. The experiments were repeated 11 times, each time by feeding 1 to 3 of the 34 rats with mature segments of *Hymenolepis nana* from infected rats and placing them in separate cages, and also at the same time isolating 1 or 2 which had not been thus fed, in order that there might be a check on the results. Constantly among the former, *Hymenolepis nana* developed in greater or less number, sometimes more than 100; among the latter no specimens whatever were found.

The rapidity with which development occurred varied in different individuals. In general, after 4, 5, or 8 days, tapeworms 3, 5, or 8 mm. long were found—that is, either with simply a long neck, or with evident proglottids. After 15 days, tapeworms were found containing mature eggs; after 30 days, the eggs began to appear in the feces.

While the results in the experiments with white rats aged from 1 to 3 months were constant and positive, when rats younger than 1 month (suckling) or over 3 months were used the results were either negative or only a few tapeworms were developed. Ordinary rats proved more refractory to infection than white rats, and the results were generally negative, even when the rats were of the favorable age— 1 to 3 months. Whether the animal was fasting or well fed, or whether many or few segments were given, had no effect on the results. Rats already harboring *Hymenolepis nana* also proved refractory to further infection.

It is in the villi of the last 10 to 12 cm. of the small intestine that the intermediate stage develops. As in *Oxyuris vermicularis*, however, the action of the digestive juices of the upper part of the alimentary canal seems necessary before the embryo will hatch. Consequently the eggs, as they escape from ripe segments into the intestine, do not continue developing, but pass out unchanged with the feces, and development does not proceed until they again come into the alimentary canal by way of the mouth [? or by reverse peristalsis into the stomach].

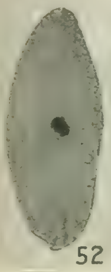


FIGS. 46-49.—*H. nana*. Enlarged. (After Grassi & Rovelli, 1892a, pl. 3, figs. 4-7, respectively.)

FIGS. 50, 51.—Hexacanth embryos of *H. nana*, with primary cavity; *calc.*, calcareous corpuscle; *caud.*, caudal appendage; *pr. cav.*, primary cavity. Enlarged. (After Grassi & Rovelli, 1892a, pl. 3, figs. 8, 9, respectively.)

The following observations were made upon the development as it occurs in the intestinal villi of the rat (Grassi & Rovelli, 1892a). The cysticercoid, or cercocystis, to use the name employed by Villot (1882) to designate those cysticercoids which have caudal appendages, is found in a cavity, which represents the much-dilated central lymphatic cavity of the villus. Rarely there are two, ordinarily only one cercocystis in a single villus, normally so oriented that its long axis corresponds to the long axis of the villus, with its posterior end (that bearing the embryonal hooks) directed inward, i. e., toward the lumen of the intestine (fig. 67).

The *first stage* studied was that of the hexacanth embryo, as found encysted 24, 36, or 50 hours after ingestion (figs. 46–49, 52, 53), generally oval, or at times flask shaped—that is, with a body and a tail. There may be evident at this time a rather ample primary cavity which in a flask-shaped embryo is in relation with the posterior part of the body, and sometimes with the tail also (figs. 50, 51). The embryonal hooks are generally found on the tail, sometimes also on the posterior part of the body, arranged in pairs. The embryos often show irregularities in form, prominences, etc. (figs. 47–49, 53). In the middle of the body there may be found one, two, or three calcare-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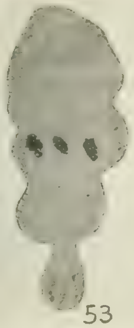
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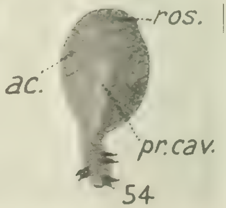

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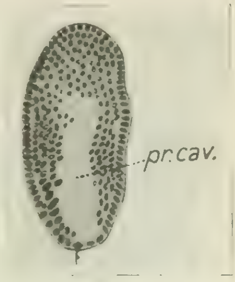

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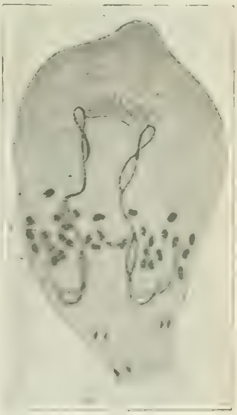
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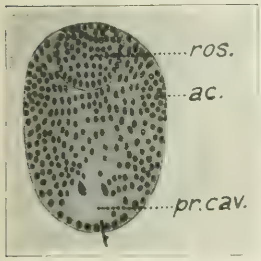

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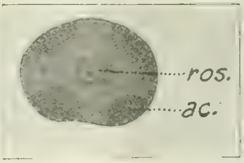

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Figs. 52, 53.—Hexacanth embryos of *H. nana* without cavity, containing calcareous corpuscles. Enlarged. (After Grassi & Rovelli, 1892a, pl. 3, figs. 10, 11, respectively.)

Fig. 54.—Embryo of *H. nana* after the appearance of the primordia of rostellum and suckers. *ac.*, suckers; *pr. cav.*, primary cavity; *ros.*, rostellum. Enlarged. After Grassi & Rovelli, 1892a, pl. 3, fig. 12.

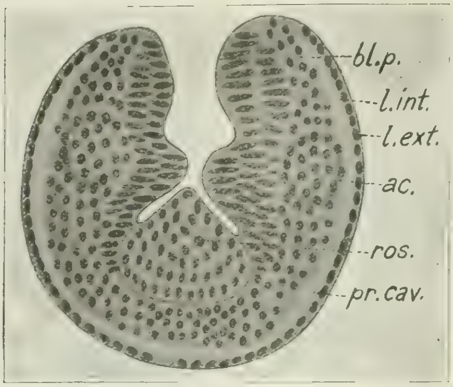
Fig. 55.—Longitudinal section of embryo of *H. nana*; *pr. cav.*, primary cavity. Enlarged. After Grassi & Rovelli, 1892a, pl. 3, fig. 14.

Fig. 56.—Longitudinal and slightly oblique section of embryo of *H. nana* after the appearance of primordia of rostellum and suckers. *ac.*, suckers; *ros.*, rostellum; *pr. cav.*, primary cavity. Enlarged. (After Grassi & Rovelli, 1892a, pl. 3, fig. 15.)

Fig. 57.—Embryo of *H. nana*. Same stage as preceding figure, in cross section. *ac.*, suckers; *ros.*, rostellum. Enlarged. After Grassi & Rovelli, 1892a, pl. 3, fig. 16.

Fig. 58.—Cercocystis of *H. nana* completely developed. Enlarged. After Grassi & Rovelli, 1892a, pl. 3, fig. 13.

ous corpuscles. The cells making up the embryo are at this stage irregularly disposed and all very small, except a few which are in immediate relation with the tail and primary cavity (fig. 55). Neither in this nor in succeeding stages was a subcuticular muscle system observed.



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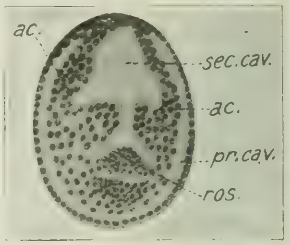

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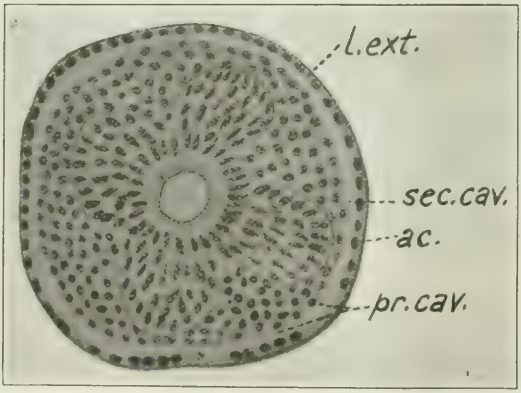

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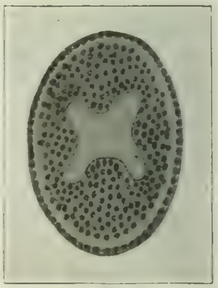

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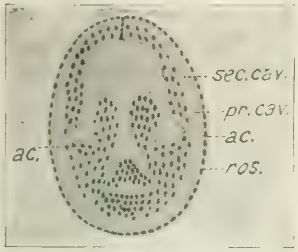
Fig. 59.—Longitudinal and slightly oblique section of *H. nana* after the invagination of its anterior portion: *ac.*, sucker; *bl. p.*, anterior opening of secondary cavity; *l. ext.*, external wall; *l. int.*, internal wall; *pr. cav.*, primary cavity; *ros.*, rostellum. Enlarged. (After Grassi & Rovelli, 1892a, pl. 3, fig. 17.)

Fig. 60.—Embryo of *H. nana*. Same stage as preceding figure, in cross section at the level of the suckers: *sec. cav.*, secondary cavity. Other letters as in preceding figure. Enlarged. (After Grassi & Rovelli, 1892a, pl. 3, fig. 18.)

Fig. 61.—Longitudinal and slightly oblique section of an embryo of *H. nana* at a stage somewhat later than fig. 59: *ac.*, suckers; *pr. cav.*, primary cavity; *ros.*, rostellum; *sec. cav.*, secondary cavity. Enlarged. (After Grassi & Rovelli, 1892a, pl. 3, fig. 19.)

Fig. 62.—Transverse section of an embryo of *H. nana* at the same stage as preceding figure. Enlarged. (After Grassi & Rovelli, 1892a, pl. 3, fig. 20.)

The *second stage*, as observed in the fresh state, still showed the cavity, and in the anterior part a deep, narrow, invaginated depression, shaped in longitudinal optical section like an inverted Y (fig. 54). At this stage, also, there are more or less noticeable four points in which the cells are so disposed as to indicate four rounded masses. Sections of this stage (figs. 56, 57) confirm the presence of the four-rounded masses, and in the region of the Y-shaped invagination there is to be distinguished another accumulation of cells, the primordium of the rostellum. Accumulations of cells were occasionally found in other regions of the embryo similar to the four masses mentioned, but since the latter appeared to be constant in many examples, both in the fresh state and when sectioned, the conclusion was arrived at that the four masses in question were the primordia of the suckers.



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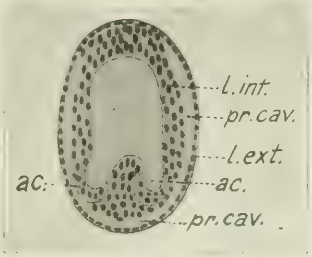

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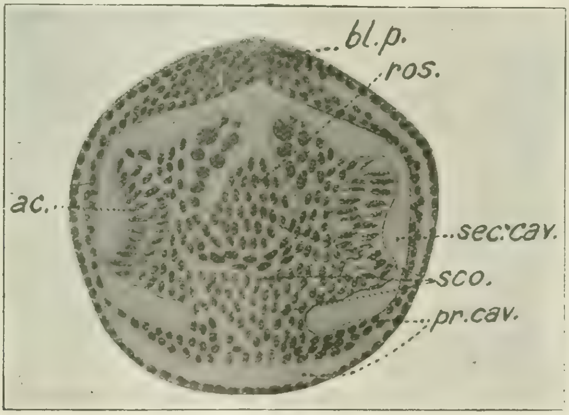


65

FIG. 63.—Longitudinal section of an embryo of *H. nana* at a later stage than preceding figures: *ac.*, suckers; *pr. cav.*, primary cavity; *ros.*, rostellum; *sec. cav.*, secondary cavity. Enlarged. (After Grassi & Rovelli, 1892a, pl. 3, fig. 21.

FIG. 64.—Longitudinal section of an embryo of *H. nana* at about the same stage as the preceding figure, through a different plane: *ac.*, suckers; *l. ext.*, external wall; *l. int.*, internal wall; *pr. cav.*, primary cavity; *sec. cav.*, secondary cavity. Enlarged. (After Grassi & Rovelli, 1892a, pl. 3, fig. 22.)

FIG. 65.—Longitudinal section of an embryo of *H. nana* at a stage preceding the appearance of the definitive hooks; the rostellum is retracted: *ac.*, sucker; *bl. p.*, anterior opening of secondary cavity; *pr. cav.*, primary cavity; *ros.*, rostellum; *sco.*, scolex; *sec. cav.*, secondary cavity. Enlarged. (After Grassi & Rovelli, 1892a, pl. 3, fig. [illegible]

The second stage is therefore characterized by the formation of the primordia of the rostellum and suckers.

In the *third stage* (figs. 59, 60, 62) the anterior part of the body is invaginated into the posterior, and the primary cavity has become reduced to the point of disappearance, or at most containing but very little fluid, except behind, where it is in relation with the tail, in which region it remains large and may contain cells of stellate form. The tail has not increased in length, and still bears embryonal hooks. Without meaning thereby to establish any homology, Grassi compares this stage to a gastrula. The anterior opening thus corresponds to a blastopore, the secondary cavity formed by invagination to an enterocœle, and the primary cavity lying between the outer and the inner wall to a blastocœle. The outer wall, analogous to the ectoderm of a gastrula, is very thin, consisting of an irregular layer of more or less flattened cells, and, external to this, a thin cuticula. The inner wall, analogous to the entoderm, is irregular and thick, apparently lined internally with cuticula. The rostellum preserves the shape it had in the former stage, but as a result of the invagination of the anterior part of the body now lies posterior of the plane of the suckers

In *the next following stages* (figs. 61, 63, 64) the suckers have moved backward, and the anterior opening of the secondary cavity has closed over.

At *later stages* (figs. 65, 66), reached 40, 50, or 70 hours after ingestion, the scolex is definitely formed. It remains attached behind to the inner wall by a peduncle. A little bridge of cuticula still indicates the place where the anterior opening of the secondary cavity has been closed over. The rostellum may be seen in a state of extension. The definitive hooks have not yet appeared. The tail persists unchanged with the embryonal hooks.

In a still later stage, reached in 80 to 90 hours after ingestion, the hooks have appeared on the rostellum, and the excretory vessels become evident (fig. 58).

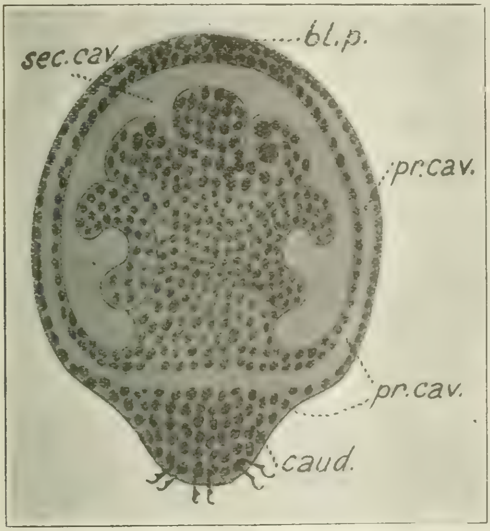
The next stage seen was that of the young tapeworm, with short neck and no trace of segmentation, attached to the epithelium of the villus.

No observations were made regarding the manner in which the cercocystis leaves its position in the villus, and becomes transformed into the adult worm.

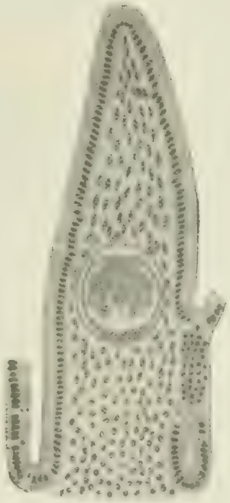
Not only was the rapidity of development found to vary in different rats, but various stages were found occurring simultaneously in the same host.

Attempts were made to infest human subjects with eggs and mature segments both from man and from rats. Experiments were made upon eight persons, but except in one case the results were negative. This case was that of a boy five years old, who, 15 days after ingesting several segments of *Hymenolepis nana* from a rat, began to pass eggs in his feces, and after the administration of an anthelmintic, expelled about 50 worms. Another instance might be mentioned here, in which a boy, who, to judge from fecal examinations, was free from

Hymenolepis, was found to be infected after a month, during which time he was accustomed to collect the feces of an infected patient for use in Grassi's experiments. As Grassi stated, however, these two cases are not conclusive, since the experiments were made in a country where the parasite is common, and since, also, the worms might have been present in the intestine without eggs being manifest in the feces. As further evidence of the occurrence of a development in man similar to that which occurs in the rat, Grassi (Grassi & Rovelli, 1892a) mentions cases occurring during the years 1890 and 1891 in children of well-to-do families. Some of the children belonging to these families would become infected, and, 2 to 4 months later, their brothers and sisters would also show infection. In such cases it seemed to Grassi that the chances are very much against the possible swallowing of invertebrates which might contain cysticercoids, and that the circumstances are arguments in favor of the occurrence of direct infection, through the feces, from one child to another. Somewhat similar evidence is given by Venuti (1895), who, according to Massari (1898), was able to explain the phenomena associated with the appearance of *Hymenolepis* among the inmates of a boys' asylum at Catania only upon the assumption that direct infection occurred. (See p. 55.)



66



67

FIG. 66.—Longitudinal section of an embryo of *H. nana* at about the same stage as the preceding figure; rostellum protracted. *bl. p.*, anterior opening of secondary cavity. *caud.*, caudal appendage. *pr. cav.*, primary cavity. *sec. cav.*, secondary cavity. Enlarged. (After Grassi & Rovelli, 1892a, pl. 3, fig. 24.)

FIG. 67.—Longitudinal section of an intestinal villus of the rat, containing a cercocystis of *H. nana*. Enlarged. (After Grassi & Rovelli, 1892a, pl. 3, fig. 25.)

In the absence of conclusive positive experimental evidence, one may not, of course, make the absolute statement that *Hymenolepis nana* develops in man after the manner determined by Grassi in the case of the rat, but it is safe to assume that a similar development occurs in both hosts, at the same time not forgetting the possibility, in both cases, that development might occur also by means of an intermediate host.

ABSTRACTS OF CASES OF HYMENOLEPIS NANA IN MAN.[a]

AFRICA.

Cairo, Egypt, 1851 -- **1 case.**

Case No. 1.—Bilharz (Siebold, 1852) was the first to observe *Hymenolepis nana* in man, when he found at the autopsy of an Egyptian boy who had died from meningitis a very large number of these worms, occupying a restricted portion of the ileum.

Cairo, 1885, 1892 -- **2 cases.**

Cases Nos. 2 and 3.—Innes (Sonsino, 1885) found a single example in the intestine of a young Nubian girl who had been drowned, and in 1892 (Innes, 1898, p. 65) encountered the parasite a second time, finding 20 specimens in the intestines of an adult, who had died from anemia. The mucous membrane of the ileum showed 5 or 6 little bloody extravasations like flea bites, and quite different from the wounds produced by *Agchylostoma* (not reported present in this case), but whether due to the tapeworms the author could not say, since the parasites were no longer adherent.

EUROPE.

Nottingham, England, 1854–1855 -- **1 case.**

Case No. 4.—W. H. Ransom (1856, pp. 598–599) in July, 1854, found the eggs of *Hymenolepis nana* in the feces of a little girl. Their identity, however, was not recognized until more than thirty years later (Grassi & Calandruccio, 1887a, p. 285; Ransom, 1888, pp. 109–110.) The girl was 9 years old, of poor parents, and lived in a low, damp locality; had always been delicate, but never seriously ill; was fond of fruit and vegetables, especially raw cabbage. In March, 1854, she began to complain of feeling faint and weak in the morning; she was treated for worms by a druggist, but without result; became gradually weaker, losing flesh, strength, and color; her appetite was capricious, but not ravenous; she suffered occasionally from a pain in the left side. The ordinary symptoms of helminthiasis (such as vomiting and nausea, convulsions, and itching of seat and nostrils; ravenous appetite and gnawing pains in the abdomen; round worms, seat worms, or tapeworm joints in the stools) were all absent. Besides the eggs of *H. nana* the feces contained eggs of the whipworm, *Trichuris trichiura*. Fecal examinations of her four brothers and sisters showed them free from intestinal parasites. In the course of the following year the patient was placed under anthelminthic treatment several times; a specimen or two of eelworms (*Ascaris lumbricoides*) and pinworms (*Oxyuris vermicularis*) were passed, but if any tapeworms were expelled they passed unperceived. With careful diet and tonics her condition was much improved, although the eggs of the tapeworm were found in the feces at each examination and were still present in September, 1855, fifteen months after the case first came under observation.

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[a] The cases abstracted have been numbered seriatim for convenience of reference, after arrangement chronologically by countries.

For additional cases see footnote, p. 7.

Milan, Italy, 1879 .... 1 case.

Case No. 5.—GRASSI (1879b, p. 156) reports a case from the Milan Hospital of a girl 4½ years old, suffering from severe nervous troubles with epileptiform attacks, the symptoms resembling those of a basilar cerebral tumor. The child was also troubled by an intermittent diarrhea. In her feces, besides the eggs of *Ascaris*, *Trichuris*, and *Oxyuris*, were some cestode eggs determined several years later (GRASSI, 1886a, b) as belonging to *Hymenolepis nana*. Kousso and kamala were administered with negative results.

Belgrade, Servia, 1885 .... 1 case.

Case No. 6.—BLANCHARD (1886e) reported the next case of *Hymenolepis* in Europe. A 7-year-old girl of poor parents came under the care of Doctor Holez of Belgrade, suffering from digestive troubles. Tapeworm was suspected and male fern administered. A *Tænia solium*, some *Oxyuris vermicularis*, and 50 *Hymenolepis nana* were passed. The treatment was repeated four or five times, about 50 examples of *H. nana* being passed each time, so that altogether about 250 were expelled. This case was also reported by LEUCKART (1886a, pp. 995–997).

Lombardy and Sicily, Italy, 1886 .... 2 cases.

Cases Nos. 7 and 8.—In 1886 two cases of *Hymenolepis nana* were observed at Milan by GRASSI (1886a, b, 1887d.) Two young Sicilians, one of whom seems to have been a medical student from near Catania, Sicily (CALANDRUCCIO, 1890a, p. 124), both of robust constitution, were affected with severe nervous troubles, indolence, epileptic attacks without loss of consciousness, weakening of the mental faculties, melancholia, and bulimia, which resisted all treatment, the symptoms generally resembling those exhibited by the little Milanese girl in 1879 (see case No. 5). Upon the discovery of cestode eggs in the feces male fern was administered, after ineffective trials with kousso and kamala, and each patient expelled several thousand specimens of *Hymenolepis nana*. Following this treatment all the morbid symptoms disappeared.

Cusago, near Milan, Italy, 1886 .... 1 case.

Case No. 9.—This case was reported by VISCONTI & SEGRÉ (1886.) On October 9, 1886, a peasant, aged 17, in a state of extreme prostration, with severe dyspnea, entered the hospital at Milan from Cusago. Toward evening the dyspnea increased, and when the patient was seen the next morning he was unconscious, respiration stertorous, lips blue, extremities cold, and pulse thready. Death supervened shortly.

Upon inquiry it was found that for three years the patient had suffered from an habitual diarrhea, passing several yellowish stools a day. He complained constantly of colicky pains in the abdomen, which often became very severe. His appetite however, remained good, and was not perverted. He had had malaria, from which recovery was complete. He suffered from frequent headaches of short duration; always felt cold; the last two months of his life had a slight fever evenings, upon which quinine had no effect; his respiration was noisy, and light attacks of dyspnea were of occasional occurrence. Three days before entering the hospital he was seized with a violent attack of dyspnea, and repeated attacks of clonic convulsions, almost epileptic in character, each lasting for some time and followed by evacuations from the bowel.

The autopsy revealed 4 specimens of *Agchylostoma duodenale* in the duodenum, and 6 *Ascaris lumbricoides* and about 400 *Hymenolepis nana* in the ileum. The tapeworms, not adherent, were scattered through the ileum from its beginning to about 20 cm. from the ileo-cecal valve. (For pathology of this case see p. 68.)

Lombardy, Italy, 1886–1887 .... 3 cases.

Catania, Sicily, 1886–1889 .... 23 cases.

Italy, 1890–1891 .... several cases.

Cases Nos. 10 to 15.—Grassi (1887d) records 6 new cases, 3 observed by him in Lombardy, and 3 by Calandruccio in Catania, Sicily. In 5 of the cases the parasites were few, and only slight nervous troubles were present. In the other (No. 12), however (one of the cases of Lombardy), the nervous troubles were very marked. An autopsy was performed on one of the cases in Catania (No. 15), which showed that the worms had bored deeply into the mucosa and provoked very considerable alterations, of which, however, no account is given.

Cases Nos. 13 to 35.—Calandruccio (1890a) reports for Catania 23 cases in all, 3 of which he states were observed by Grassi. It is possible that the 2 cases of the young Sicilians (7, 8) reported by Grassi (1886 a, b, 1887d) are to be included in this number, but there seems to be some confusion in the reports of these two authors as to the identity of the various cases and a certain lack of definiteness, so that it is not possible to state the figures with accuracy.

The persons examined were mostly young and of the male sex: 21 cases were children, 2 adults: 14 at least were males, and 3 females, very likely the other 6 were males. In the feces of 20 children, aged 8 to 10 years and attending the same rural school in Catania, the eggs of *Hymenolepis nana* were found 3 times, together with the eggs of *Ascaris*, *Oxyuris*, and *Trichuris*. Of 50 boys, aged 7 to 10 years, in the Ospizio di beneficenza of Catania, 4 harbored the parasite.

Case No. 32.—Calandruccio observed the case of a young child, who suffered from severe intestinal troubles, which ceased two days after the expulsion of a great number of *Hymenolepis nana*.

Cases Nos. 33 and 34.—He also mentions in some detail 2 cases, adults who harbored numerous specimens. They suffered with alternating diarrhea and constipation, not infrequently with abdominal pains, and with more or less severe epileptic attacks of frequent occurrence. After the elimination of the parasites, the patients experienced no disturbances for several months. The symptoms later reappeared, but were less intense and less frequent. The feces were reexamined on a number of occasions, but no eggs of *Hymenolepis nana* could be found. This circumstance made it seem very probable, according to Calandruccio, that the two individuals were inherently epileptic and the effect of the tapeworms had been that of aggravating the symptoms and rendering them more intense and more frequent.

Case No. 35.—The case of a female child, 4 years old, is referred to by Grassi & Calandruccio (1887a). Although this patient harbored thousands of *Hymenolepis*, she showed no symptoms except occasional abdominal pains of transitory nature.

Grassi (Grassi & Rovelli, 1892a) speaks of several cases occurring during 1890–1891 among children of well-to-do families, but gives no detailed account of them.

Varese, Italy, 1884–1886

2 cases.

Case No. 36.—Comini (1887 a, d, 1888 a) reports a case of *Hymenolepis nana* in a boy, 9 years of age, born and living in Gavirate. The parents of the patient were healthy, but a paternal aunt had died with symptoms of insanity. At 14 months of age he had been treated with santonin for worms; after taking the drug his skin became cold, the lips and face blue, eyes staring, and body stiffened. After recovering from the immediate effects of the santonin he was left with a slight paresis of the extremities of the right side; this symptom, however, disappeared in a month without leaving any traces. He passed a great number of *Oxyuris* in June, 1884, after treatment with an anthelminthic clyster. On July 4 the boy was seen to become suddenly pale and comatose. After a few minutes the condition of coma was succeeded by violent clonic contractions, trismus, and foaming at the mouth. This convulsive attack lasted about two hours, and was followed again by coma of several hours' duration.

On the 25th of August there were a couple of attacks of an epileptic nature, which up to the 14th of September were of daily occurrence, sometimes as many as 6 in twenty-four hours. After this the attacks ceased.

In July, 1886, nearly two years later, there was a recurrence of the nervous symptoms. Eggs of *Hymenolepis nana* were found in the feces. Up till October the child suffered with severe cerebral troubles and epileptiform attacks. The eggs were still abundant in the feces. Extract of male fern was prescribed. Although the worms were not found in the stools after the treatment, the eggs disappeared from the feces, and the attacks ceased. In the latter part of December (Comini, 1887a, p. 61) the attacks again recurred more severe than before, and the eggs likewise had reappeared in the feces. Comini (1888a) is rather doubtful as to the etiological importance of *Hymenolepis* in this case, in which there wás already an apparent congenital predisposition to nervous disease.

Case No. 37.—A second case was observed December, 1886, by Comini (1887 a, d, 1888a) at the hospital in Varese.

The patient, a little girl of 3 years, with a tuberculous mother, had suffered for two years with a continual dyspnea, without fever or cough, but often accompanied by pains in the abdomen, and functional gastro-intestinal disorders. Eggs of *Hymenolepis nana* were numerous in the feces (7 to 8 in every preparation). Eggs of *Ascaris* were also present.

After anthelminthic treatment the dyspnea became gradually better and disappeared entirely in a few days. A year later the child was in excellent physical condition, and the feces were free from eggs of *Hymenolepis*.

Pavia, Italy, 1886–1889 . . . . 6 cases.

These 6 cases were observed in very complete detail by Senna (1889) at the clinic of Professor Orsi, who also published a short paper (Orsi, 1889) in regard to them.

Case No. 38 (Senna's Case I).—Epileptiform convulsions with intestinal helminthiasis.

Female, 15 years of age, domestic. Always weak and of a delicate constitution, she had suffered for three years from convulsive clonic attacks, with foaming at the mouth and complete loss of consciousness. These attacks were at first fleeting and occurred only at long intervals, but as time went on became more frequent and insistent, especially at night. There were present also gastric dyspepsia and troublesome abdominal paresthesia, with a sense of constriction in the fauces. Anthelmintics had been tried with no apparent result. She had also had at one time a convulsive cough which lasted a year, a suppurating keratitis of the right eye, and frequent inflammation of the cervical glands. Her father and brother were both healthy, but the former, a day laborer, was somewhat given to drunkenness. Neither nervous maladies nor pellagra was known in the family; a paternal uncle had died of consumption.

The patient entered the clinic the last of November, 1886. The convulsive attacks continued, occurring almost every night, and rarely in the daytime. Some nights the attacks were very transitory and passed almost unperceived by the nurse. The girl was somewhat melancholy, taciturn, and preferred solitude. She was, however, of good intelligence, and careful physical examination revealed no morbid organic conditions of importance. Examination of the feces showed numerous eggs of eelworms (*Ascaris lumbricoides*), a very few of hookworms (*Agchylostoma duodenale*), a few of whipworms (*Trichuris trichiura*), and of *Hymenolepis nana*. Several eelworms were passed after the administration of santonin, but no tapeworms were seen, nor were any of the latter perceived in the stools after treatment with ethereal extract of male fern. Some tapeworms, however, were undoubtedly expelled, since the eggs were no longer to be found in the feces. The patient improved, and left the hospital the latter part of December.

Amelioration lasted only a few months; the convulsions came on again, and the patient returned to the hospital in April, 1888. As before, she suffered with epileptiform convulsions almost every night, more rarely by day, often accompanied by involuntary micturition; there were occasional manifestations of somnambulism. She was more taciturn than before, and somewhat stupid. Eggs of *Ascaris* and *Hymenolepis* were again found in the feces. Male fern was administered, but no worms were obtained. The patient, after a month, left the hospital.

She returned a third time in the middle of April, 1889. For some time after leaving the hospital she had been fairly well, but more recently the convulsions had reappeared, and occurred almost every night. She had menstruated for the first time in August, 1888; afterwards only in October, and again in February. The girl is still more melancholy and self-centered than before, does not wish to associate with any one, is restless, inclined to lament over everything, and is very slow and unwilling in answering questions. Physically she is fairly well developed, but is somewhat pale and languid. There are evident scrofulous signs—a peculiar softness of the skin, tumid lips, scar on the right eyeball from keratitis, sinistral cervical adenitis. The head is of normal size and shape, intelligence good, no defects in the special senses, appetite and thirst moderate, tongue coated, breath fetid, digestion difficult, defecation and uropoietic functions more or less regular, a rough diffuse vesicular murmur in the chest, no cough nor dyspnea. Patient complains of a troublesome abdominal paresthesia, a sensation as of a snake crawling through the abdomen and up to the fauces, with a sense of heat in the epigastrium, and strangulation at the throat. This sensation is often more intense before the daily convulsive attack. The pulse is regular, urine normal, and there is no fever. In the feces are eggs of *Ascaris*, *Trichuris*, and a few of *Hymenolepis nana* (1 to 2 per slide).

After entering the hospital the patient had one convulsive attack during the daytime. She fell suddenly, with diffuse clonic spasms, foamed at the mouth, and was entirely unconscious. When seen by Senna she was in a comatose condition, not responsive to command nor reacting to cutaneous stimuli; the pupil was not abnormally dilated and reacted a little to light. Another day she was observed during an attack of diffuse tremor, which she said was of frequent occurrence. Almost every night she was taken with fleeting convulsive attacks, moved arms and head, foamed at the mouth, and uttered a groan or a whistling sound. In the morning she had no recollection of the occurrence.

Five grams ethereal extract of male fern, followed by a purgative, were administered. In the copious watery stools no tapeworms could be found, but for several days following the patient was much improved, no longer felt the peculiar sensations in the epigastrium and throat, and was not troubled with the muscular spasms. The eggs of the tapeworm were absent from the feces. After a short time light convulsive attacks during the night again appeared, but the patient felt so much improved that she left the hospital toward the end of the month.

It is evidently not possible in this case to establish an absolute connection between the epileptic attacks and the presence of *Hymenolepis nana*, since a complete and lasting cure was not attained, and since the patient was scrofulous, debilitated, and the child of an alcoholic father. It is certain, however, that she improved after each treatment, and it is justifiable to consider, Senna thinks, that the presence of *Hymenolepis nana*, and perhaps also of the other intestinal worms, if not the sole cause, at least had great influence upon the epileptiform manifestations, since they reappeared or became less frequent in correspondence with the presence or absence of eggs in the feces.

Case No. 39 (Senna's Case II).—Epileptiform convulsions, with intestinal helminthiasis (*Hymenolepis nana*).

School girl, 16 years old, native of Stradella, Lombardy. Mother died in childbirth; three brothers and one sister dead; causes not known. One brother living; healthy. Father living; inebriate.

The patient had always been in the best of health until the year before, when she had an attack of typhoid fever. She menstruated for the first time in December, 1887, and since then only in the middle of March. Had worked for four years at Milan as a weaver; came to Pavia in October, 1887, to live with her grandmother and attend school. Two months before entering the hospital she began to suffer with severe headaches, especially while working, and after eating; she also noted an increase of appetite, and a slight cardiac palpitation on muscular effort. Digestion and bowels remained regular. About a month after the beginning of these symptoms, the patient was rudely accosted by some soldiers. She was not much frightened at the time, but on reaching home she was taken with a convulsive attack. From this time similar attacks were experienced nearly every day, frequently two or three times. She would be found on the ground, unconscious, with a bloody froth at the mouth, and biting her tongue. Together with these symptoms there was an acute pain in the epigastrium, a sense of constriction in the fauces, and frequently after the attacks, diplopia.

The patient came to the hospital the middle of March, 1888. She was physically well developed, somewhat pale, the gait was normal, decubitus indifferent, intelligence good, character mild and tranquil, no alteration in the special senses, nor in the sensibility and mobility of the face and cervical muscles. The eyes appear somewhat salient, react regularly to light, movements of the bulb intact, except occasional diplopia from insufficiency of the right rectus internus. Tongue normal in size, form, and direction, with a number of shallow furrows in the mucosa of the anterior two-thirds, irregularly disposed and filled with a whitish scum. There is increased appetite without malacia or pica, thirst moderate, speech and deglutition normal. There are no abnormalities of neck or chest. The form and volume of the abdomen; gastric, intestinal, uropoietic and menstrual functions; pulse, urine; the motility, sensibility, and reflexes of the extremities are all normal. Complete apyrexia. The feces contain eggs of *Ascaris*, *Trichuris*, very few of *Agchylostoma duodenale*, and a great many of *Hymenolepis nana*, 7 to 8 or more in every preparation. Besides the severe headache, the patient complains of a painful sensation of strangling, which is almost continuous, often more intense just before the onset of a convulsive attack, and of a persistent pain in the epigastrium, exacerbating on palpation. The last sensation is often that of a severe gnawing.

At the beginning of her stay at the hospital she had a convulsion nearly every day, and sometimes two or three. The onset of the attack is usually sudden, sometimes preceded by an intense pharyngeal spasm. During severe attacks consciousness is entirely lost. The patient falls with a groan, the face is pale with an astonished expression, eyes fixed and expressionless, with a slight mydriasis. The superior extremities, especially the right, are shaken with coarse, irregular, clonic movements, the trunk is bent to one side, frequently the left, and the lower extremities exhibit diffuse clonic spasms with vibrations finer and more rapid than those of the upper.

The pupils are not affected by light; there are no losses of urine or feces; sometimes there is a slight foaming at the mouth. After a few seconds the patient gives signs of regaining consciousness, but for some minutes the face retains its look of astonishment and the eyes their expressionless stare. After the convulsive attack she complains for several hours of headache and remains somewhat depressed; does not recall having had the attack.

After treatment no worms were found in the feces, but the eggs were afterwards absent. The abdominal pains and the pharyngeal spasm disappeared and the epileptiform attacks were much diminished in frequency. Eggs having again been found in the feces, treatment was repeated, and the attacks ceased entirely for fifteen days. At the end of this time they returned, but much less intense than at first, and the girl left the hospital, uncured, in June, 1888.

More recently Senna saw the patient, who told him that she suffered from the convulsions for four months after leaving the hospital, but they then disappeared and had not since returned. She felt entirely well and appeared happy and in the best of health.

Case No. 40 (Senna's Case III).—Sinistral hemiparesia and other diffuse nervous disturbances (from *Hymenolepis nana?*).

School girl, 11 years old, from Sanazzaro. Family history good. According to her mother, child was always bright, vivacious, and of a sweet and affectionate disposition.

In the beginning of February, 1889, it was noticed that the girl, when standing or walking, swayed upon her legs as if to fall. When talking, the angle of her mouth was drawn toward the right side. She complained of slight headaches, and occasional vertigo; fell to the ground one day while going to school. The appetite and digestion remained good, there was no fever, no vomiting, no spasms of any sort, and the child continued to go to school with no appreciable change in character or intelligence. Little by little walking became more difficult, the left arm and leg became weakened, and there was often diplopia.

The patient entered the hospital the 18th of February, 1889. She is well developed for her age; of healthy color. Gait is uncertain and vacillating, and left leg drags. The eyes are fixed, and she carries the head inclined toward the left shoulder with the chin turned to the right. Closing the eyes has no effect on the gait. The decubitus is indifferent, patient is calm, and the sleep tranquil. Form and size of head is normal. There is considerable deficiency in the action of the muscles on the left side of the head. Special senses are normal; pupils somewhat dilated, normal in reflexes and accommodation. Moderate degree of convergent strabismus, the movement of the right eye outward being deficient; occasionally there is a slight nystagmus; the patient no longer complains of diplopia. Epiphora of the left eye, lachrymal duct open; anesthesia of cornea and conjunctiva. No objective change in the sensibility of the face, no tender spots. Tongue and uvula deviate to the right. Appetite is good, thirst moderate. Phonation, mastication, and deglutition normal; no abnormal sensation at the throat, no painful spots nor spasms in the neck. No pains nor abnormal sensations in chest or abdomen; digestion and other functions regular. Examination of the spinal column negative; attitude of extremities normal; no change in sensation, no muscular spasms. Weakness of the extremities of the left side. Painful sensation of tingling and formication on the left side of the body (excepting the face). Electro-muscular contractility same on both sides; the cutaneous and tendinous reflexes are regular, with the left patellar reflex a little more conspicuous than the right. Urine and pulse are normal. No fever. Eggs of *Hymenolepis nana* present in the feces to the number of 5 or more in every preparation. After the administration of 3 grams of ethereal extract of male fern an extraordinary number of the tapeworms were passed.

In diagnosing this case Orsi excluded cerebral tumor on account of the rather rapid rise of the morbose phenomena, unaccompanied with much pain, partial or general spasms, or vomiting. Tubercular meningitis was excluded by the lack of tubercular or scrofulous antecedents, and the absence of febrile symptoms and of abdominal or thoracic tuberculosis. The symptoms were similar to those of a cerebral hemorrhage with multiple foci, but the age of the patient rendered this diagnosis very doubtful. Senna remarks upon the possibility of a reflex paralysis from irritation caused by the parasite.

After the elimination of the worms the patient became no better, although her feces no longer contained eggs. She left the hospital the 8th of March, continued to grow worse, without the reappearance of eggs in the feces, and returned again to the hospital in the early part of April. She was still intelligent, but appeared to be dazed and could speak only with great difficulty. The sinistral hemiparesia was more marked, and the right leg had become weakened. The other symptoms were as before. Male fern was administered without results. The patient died a few weeks later, in the early part of June, 1889, after suffering for three or four days with a violent headache, especially on the right side, and a high fever. No autopsy was made.

Case No. 41 (Senna's Case IV).—Complete paralysis of the right external oculomotor, and corresponding facial paresis, with *Hymenolepis nana.*

Female, 7 years old, daughter of a fruit vendor, from Borgorato Mormorolo (Voghera). Family history good; no preceding illness of any importance. In September, 1888, the patient began to show a weakness in the extremities of the right side; gait became irregular; the mouth was drawn to the left; when she held anything in her hands clonic convulsions of the right arm were often observed. Toward the middle of February, 1889, diplopia and convergent strabismus, affecting the right eye, appeared. Shortly after this she began to have slight headaches at intervals; her intelligence remained good but speech became difficult. An anthelmintic was administered; the general state of her health was improved, but the strabismus persisted.

The patient on examination appeared well developed, and of healthy color. She walked very well, but exhibited a little uncertainty in rapid movements, and held the head slightly inclined toward the right shoulder. She no longer complained of weakness of the right arm and leg, nor of headache. She was quite intelligent, the size and form of the head were normal, there was no objective change in the sensibility of the face, senses normal, no tender spots nor spasms. There was apparently complete paralysis of the right rectus externus, the eye could be moved upward or downward, but lateral movement was impossible. Diplopia was present. The pupils were regular and reacted well to light. The left angle of the mouth was drawn upward and outward. The appetite was good; thirst moderate; the tongue normal, deglutition good; speech difficult, but according to the patient, improved somewhat compared with its former condition. There was an occasional dry cough, somewhat spasmodic; now and then a deep sigh. Neck, chest, and abdomen normal. No pains nor paresthesia in abdomen.

The gastro-intestinal and uropoietic functions were regular. There were no objective evidences of diminished power of the limbs, and hyperkinetic manifestations and alterations of sensibility were absent; reflexes persistent. Urine and pulse regular. No fever. The feces contained the eggs of *Hymenolepis nana* and *Ascaris lumbricoides* in moderate numbers. Three grams of ethereal extract of male fern followed by a purgative were administered and a large number of *H. nana* were expelled. The speech and gait were much improved in a few days, although the strabismus and deviation of the mouth continued. The strabismus finally showed signs of amelioration, and the right eye could be moved outward to a barely perceptible degree. The eggs were no longer present in the feces.

Case No. 42 (Senna's Case V).—Chronic chorea minor caused by *Hymenolepis nana.*

Boy, 11 years old, peasant, from Cervesina. Family history good. Operated upon when a baby for vesicular calculus; has had malaria; and several times intestinal helminthiasis, with violent colic, without reflex nervous phenomena; cured after the expulsion of ascarids with santonin.

In January, 1889, the patient began to experience a difficulty in talking and in moving his tongue. Some days later he was affected with convulsive movements of the head and face, then of the arms. Afterwards the trunk and lower extremities became similarly affected. His condition continued to grow worse, and he entered the hospital in the latter part of April.

The patient is tolerably well developed, with fine skin and rather pallid mucous membranes. Irregular, clonic, involuntary muscular contractions occur continually, sometimes involving the entire body, which render the erect posture and the gait uncertain and vacillating. In brief, the symptoms are those common to chorea minor. Everything that excites or stimulates the patient aggravates the muscular agitation, which can not be controlled in the least by the will. The sleep is tranquil, and nocturnal muscular spasms are absent. He is intelligent; the speech, however, is incoherent, monosyllabic, and at times almost incomprehensible. The pupils are unequal, sometimes one, sometimes the other being the larger, but they react well to light. Vision is diminished in the left eye, there is diplopia, and unilateral convergent strabismus, due to insufficiency of the left rectus externus. Special senses and sensibility of the face are normal. Appetite and digestion are good. Apex beat of heart in fourth intercostal space in the nipple line, and heart of normal size. The systole is accompanied by a slight blowing murmur at base and apex. Size of liver normal. Spleen very slightly enlarged. There is pain and a sense of pressure in the epigastric and umbilical regions. The abdomen is regular in form and volume. The gastro-intestinal and uropoietic functions are normal. Examination of the spinal column resulted negatively. Excepting the choreic movements, the nervous system showed no abnormalities in the trunk and extremities. The pulse and urine are normal and there is no fever. In the feces are eggs of *Trichuris*, *Ascaris*, and *H. nana* (2 to 4 per slide).

The administration of 4 grams of extract of male fern was followed by the evacuation of about 50 tapeworms. The next day the patient was in a state of prostration, with severe pains in the abdomen. The following day he was resting much easier; after that improved rapidly and was soon entirely well. Eggs of *Hymenolepis nana* were no longer to be found in the feces.

Case No. 43 (Senna's Case VI).—School girl, 11 years old, from Sommo. Family history good, and patient had always been in good health.

In January, 1888, the patient became taciturn and seemed stupid; weakness and irregular clonic spasms appeared in the extremities of the right side, and after a short time the speech was affected and became difficult. There was diplopia: the mouth was drawn upward on the right side; there were also headache, pharyngeal spasms, paresthesia and pains in the abdomen, but functional troubles were absent. The symptoms became worse, and by Fall the spasms had begun to affect the left side, but with less intensity. Anthelmintic powders containing santonin were administered repeatedly without result. In December a teniafuge of unknown composition was given, and the patient became much better, so that by the end of a month she was entirely well. After three months, however—in March, 1889—the symptoms suddenly reappeared, but less intense and more intermittent. The child was brought to the hospital in May.

The patient is rather slender, with fine pale skin. She is reserved and taciturn, has some difficulty in moving the extremities of the left side, has headache, and paresthesia and pain in the abdomen, with crawling and gnawing sensations. She also experiences a feeling of constriction at the throat, and sometimes diplopia. Objective examination reveals nothing noteworthy except a slight diminution in the muscular strength of the left arm, possibly also of the leg. Clonic muscular movements, limited to the left hand and forearm, appear at long intervals. The eggs of the *H. nana* are present in the feces. Extract of male fern was administered, and, although no worms were seen in the stools, all the symptoms disappeared very shortly.

Piedmont, Italy, 1886–1887 .... 1 case.

Case No. 44.—At a meeting of the Academy of Medicine of Turin, Perroncito (1887) reported the first occurrence of a case of *Hymenolepis nana* in Piedmont, communicated by Doctor Airoldi, and later (1891) gave a fuller account.

The patient was a male, 19 years old, peasant, of robust constitution, and up to the age of 14 or 15 had not been ill, with the exception of an occasional abdominal pain during childhood. He had a doubtful case of typhoid fever, lasting a week, in the Fall of 1885.

At the time of examination, January, 1887, the patient complained of headache, sense of fatigue in the lower limbs, numbness in the lumbar region, and malaise, more pronounced after the least exertion. Slight pains in the joints were attributed to the irregular life which the boy had led between the age of 13 and 15, when he wandered about in the fields in all sorts of weather, hunting for birds. For two years he had experienced frequent attacks of vertigo, and losses of consciousness lasting about a minute. The physical examination showed no abnormalities. The feces contained numerous eggs of *Hymenolepis nana.*

After treatment the patient passed a large number of worms, and the symptoms rapidly subsided. In December, 1888, he was in perfect health, and more recently, according to his father, was still entirely well, with no return of his former trouble.

Sommariva del Bosco, near Turin, Italy, 1887–1888 ...... 1 case.

Case No. 45.—PERRONCITO & AIROLDI (1888 a, b, c) report the case of a boy of 6 years. Two years before he came under observation he had suffered from an attack of typhoid fever at Turin, and during convalescence was sent to the country and placed on a raw-meat diet. Soon afterwards he began to pass segments of *Tænia saginata.* He also suffered from headache, abdominal pain, lack of appetite, and frequent vomiting, the symptoms altogether indicative of gastro-enteric and nervous disturbances due to helminthiasis. The case was seen for the first time in November, 1887, when the feces were found to contain eggs of *Tænia saginata* and large numbers of the eggs of *Hymenolepis nana.* A dose of 4 grams of ethereal extract of male fern was administered, most of which was vomited; a number of pieces, however, of *Tænia saginata* and about 1,000 *Hymenolepis nana* were passed.

On May 24, 1888, the case was again examined. According to his parents the boy was often ill, with frequent pains in head and abdomen, lacked appetite, and vomited frequently. The patient appeared rather more pale than at the former examination. The stools, as before, contained eggs of *Hymenolepis nana* and of *Tænia saginata.* A purge was given the 24th, and several pieces of *T. saginata* were passed. The next day the boy was placed on special diet, and another purgative administered that evening. On the morning of the 26th he was given 6 grams of ethereal extract of male fern, and in an hour and a quarter afterwards 15 grams of castor oil. (Some of the male fern was vomited three-quarters of an hour after administration). At about noon the evacuations began; a *Tænia saginata* about 4.5 meters long and more than 1,000 *Hymenolepis nana* were passed.

Tuscany, Italy, 1889–1895 .... 5 cases.

SONSINO (1889, 1891, 1895a) has reported 5 cases of *Hymenolepis nana* from the neighborhood of Pisa.

Case No. 46.—In October, 1889, the feces of a 9-year-old girl from the Comune di Cascina, who had been suspected of uncinariasis, were sent to Sonsino for examination. Eggs of *Hymenolepis,* but none of *Agchylostoma,* were found. The girl died shortly afterwards of a febrile malady (SONSINO, 1889, 1891).

Case No. 47.—The second case (SONSINO, 1889, 1891), which was that of a man from Pisa, likewise suspected of uncinariasis, was seen in the same month. Ethereal extract of male fern gave no apparent results. The man was afterwards treated with thymol, some *Agchylostoma* were passed, but he continued to suffer from gastro-enteric troubles. As late as April, 1890, his feces still contained eggs of *Hymenolepis,* but less in number than at first. This patient was again examined five years later (Sonsino, 1895), and eggs of *Agchylostoma,* evidently from a new infection, were found in large numbers, but none at all of *Hymenolepis nana.*

Case No. 48.—A 7-year-old girl from a family of brickmakers of the same locality as that of the first case (Comune di Cascina) was brought in April, 1891, to SONSINO (1891, 1895a), to be treated for possible uncinariasis. The parents of the child were strong and healthy; during the first two years of her life the child herself was perfectly well, but after that began exhibiting evidences of a perverted appetite, and would eat mud, plaster, charcoal, and even feces of animals. Her health suffered and she grew pale. At about the age of 6, consequent upon a change of habitation to a spot where she no longer had so many opportunities of satisfying her depraved appetite, and where she could be watched more closely, she was cured of the habit. Her physical condition did not improve, however, and she continued to be subject to fatigue, cardiac palpitations, and dyspnea. Her appetite was, if anything, greater than normal, and she suffered from frequent indigestion.

On examination the patient appeared somewhat cachectic, due rather to the waxy appearance of the skin than to any actual emaciation. The lungs, heart, liver, spleen, and kidneys were normal; the abdomen was not painful on palpation, but digestion was difficult, with frequent acid eructations. The patient often complained of transient pains in the body and limbs. The cervical glands were slightly enlarged and the voice was rather hoarse. Fecal examinations showed neither eggs of *Agchylostoma* nor of *Oxyuris*. Occasional eggs of *Trichuris* and some of *Ascaris*, and one or two per slide of *Hymenolepis nana* were found. Treatment with santonin and castor oil expelled several *Oxyuris*. The next morning after this treatment extract of male fern and calomel were administered. In the first three of the five stools which followed during the day, *Oxyuris* and more than 100 *H. nana* were passed, while in the last two only *Oxyuris* were expelled.

Notwithstanding the apparent success of the treatment the patient became no better. Eggs of *Hymenolepis* were no longer present in the feces, but *Ascaris* and *Trichuris* eggs were still to be found. Treatment was again instituted, and *Oxyuris* and *Ascaris* were passed, but neither *Hymenolepis* nor *Trichuris*.

Several months later, in November, 1891, Sonsino (1895a) again examined the feces of this patient, and found the eggs of *Hymenolepis* more numerous than before. Electuaries of male fern and calomel were administered twice and vomited each time. The second time some of the dose undoubtedly took effect, as about 250 *H. nana* in fragments were expelled. A third dose a few days later expelled about 15 *H. nana*, and a large number of *Oxyuris*.

In January, 1894, the feces were free from *Hymenolepis* eggs, but contained those of *Ascaris*, *Trichuris*, and *Agchylostoma*. After two treatments with santonin and thymol a couple of male *Agchylostoma* were expelled.

Finally, in May, 1895, the feces were free from eggs of parasites, except a few of *Trichuris*, and the patient was in a state of comparative health, considering her scrofulous constitution.

Case No. 49.—The fourth case (Sonsino, 1895a), first observed in October, 1892, was a boy, 23 months old, from a family of brickmakers of the same locality as that of the first and third cases. Seven members of the family had had uncinariasis. The child's feces contained large numbers of *Hymenolepis* eggs, but none of any other parasite. Until the age of 8 months, mother's milk had been his only food, and up to that time he remained perfectly well. He then began to eat other food also, and likewise to suffer from lienteric diarrhea, with frequent vomiting and motor disorders, such as shivering, biting the lips, gritting the teeth, strabismus, and an almost continuous automatic lateral movement of the head of the nature of a clonic partial spasm (spasmus nutans), referable to a lesion or functional disorder of the spinal accessory nerve. The boy was weaned entirely and his symptoms gradually became worse.

When seen by Sonsino the patient exhibited the motor disorders noted above, complained also of pains in the abdomen and head; his nose itched very often, and he was suffering from an intense intestinal catarrh. The abdomen was flatulent, but not sensitive to pressure. There was some fever, and the patient was inclined to be drowsy.

On October 27, after treatment with male fern suspended in mucilage, and calomel, about 1,000 *H. nana* were passed. The next day the boy had improved, the fever had subsided, and the intestinal and motor troubles showed signs of diminishing.

When seen on December 11, the patient had gained flesh and color, but the diarrhea had returned. *Hymenolepis* eggs were again present in the feces. On December 19, male fern was administered and over 120 worms were passed.

On January 22, 1893, eggs were again found, and after another dose of male fern, from a portion of the evacuations following 200 worms were collected.

Three months later the boy was feeling fairly well. He had no diarrhea, and slept well, but there was still some lateral movement of the head. Eggs were found in the feces at this time, but no repetition of the treatment was attempted.

In June of the next year the patient was seen again. He was well nourished, lively, and intelligent, but, although in good condition, was not entirely cured of his former trouble. The strabismus was still present, and the lateral movement of the head still occurred, but only at intervals. For some days he had been suffering again from diarrhea. Two months before also he had had an attack of abdominal pain with fever, which lasted two days. The feces contained eggs of *Hymenolepis* and *Trichuris*. After treatment with male fern and calomel, about 100 *Hymenolepis* were passed.

At an examination made about one year later, the feces were found entirely free from *Hymenolepis* eggs, but containing an abundance of *Ascaris* eggs. The clonic spasms of the neck still continued, due perhaps to the reflex irritation from the *Ascaris*.

Case No. 50.—Rossini, of Pisa, treated a well-to-do young man, 20 years old, from Pescia, near Pisa, for *Tænia*. Besides a *Tænia saginata*, about 1,000 *Hymenolepis nana* were passed as a result of the treatment, and the specimens were referred by Rossini to Sonsino (1895a) for determination. An anamnesis of this case could not be procured.

St. Petersburg, Russia, 1890 .... 1 case.

Case No. 51.—In 1890 Professor Afanasyeff, according to Guseff (1892a, 1893a), found a case of *Hymenolepis nana* at St. Petersburg.

Moscow, Russia, 1892 .... 1 case.

Case No. 52.—Guseff (1892a, 1893a) reports a case of *Hymenolepis nana* in a child 1¼ years old at Moscow. About 200 worms were passed after treatment. This case is also mentioned by Zograf (1893).

Cologne, Germany, 1892 .... 1 case.

Case No. 53.—The first case of infection with *Hymenolepis nana* in Germany was reported from the Bürger-Hospital, at Cologne, by Leichtenstern (1892), and more at length by Mertens (1892).

A boy 6 years old was brought to the hospital in March, 1892, to be treated for *Oxyuris*. According to his mother he picked at his nose a great deal, had never shown, however, any symptoms of intestinal disorder, nor had he ever suffered from any nervous affection. Examination showed the patient healthy in every respect. Feces were normal in color and consistency, with an occasional *Oxyuris*, and eggs of *Hymenolepis nana*. Santonin was administered for 3 days in doses of 0.025 grams daily. *Oxyuris* were passed, but no tapeworms. Five grams of male fern in 2 doses, followed by salts, were then tried, and 300 to 350 *Hymenolepis* were passed. The patient experienced no bad effects from the treatment and left the hospital in a day or two. Eggs were not present in the feces until after a lapse of about 15 days, when they reappeared. In May the boy returned to the hospital. A number of enumerations gave a result of 6,400 eggs to 1 cc. of feces. Three doses of male fern, 2.5 grams each, followed by salts, were administered, and 305 worms were passed. An hour or two after the last dose the child became very restless, and cried on account of pain in the abdomen. The abdomen was hard and tense, but not swollen; the legs were doubled up. Severe and repeated vomiting occurred. The first and second vomiti had the characteristic odor of male fern. The abdominal pains ceased in the afternoon, but the vomiting continued until late in the night. On the 13th day eggs again appeared in the feces. On the 20th day there were 1,500 eggs in 1 cc. of feces. In June thymol was tried, but no worms were passed, and the eggs continued present in the same number. Three days later 8 grams of male fern in 3 doses, which were well borne, were administered, and 70 worms were passed. On the 14th day eggs again appeared.

Numerous *Oxyuris* were expelled at each treatment. Charcot-Robin crystals were not present in the feces.

Naples, Italy, 1892–1896 ....4 cases.

Out of 73 children, aged from 1 month to 12 years, examined in the pediatric hospital at Naples, CIMA (1893a, 1896a, 1896b) reports 34 cases of helminthiasis, 4 of which were infections with *Hymenolepis nana.*

Case No. 55 (Cima's Case 33).—Boy, aged 8 years, from the city, showed a slight trace of rachitis. Feces contained eggs of *H. nana.* During a single day's stay at the hospital he gave no signs of disturbances which could be traced to the action of parasites.

Case No. 55 (Cima's Case 56).—Boy, 7 years, from the city, chronic intestinal catarrh. He was brought to the hospital on two occasions. According to his father, the boy had suffered for two years with a bloody diarrhea, and had grown thin and pale. "Feces showed elements common to those of anemic patients," and eggs of *Hymenolepis nana* were observed in every preparation. Rectal injections of boric and tannic acids were prescribed, with what effect is not known as the patient was not seen again.

Case No. 57 (Cima's Case 65).—Girl, 10 years, from the city, with nervous disturbances. Fifteen days before entering the hospital the patient began to experience difficulty in walking, and in four or five days the trouble became so pronounced that she was not able to leave her bed; at night she complained of pains in the shoulders, loins, and legs. The pains diminished after a few days but an uncertainty in the gait remained, together with a sensation of formication and itching of the trunk, especially in the mammary region. No disturbances in the movements of the hands or arms were observed. The gait resembled that of ataxic or choreic subjects. The left leg dragged a little also. When the eyes were closed, the gait became more incoordinated, she often tottered, and would fall if not supported. There were no pains in the spine or legs, the general sensibility and special senses were intact; patellar reflexes were a little exaggerated; electrical tests showed nothing abnormal. The symptoms could not be assigned to any known clinical type, and rest and a hygienic diet were prescribed. In a day or two the symptoms ameliorated, the left leg was no longer dragged; blindfolded, she still walked badly, with a tendency to turn to the right. On the fourth day she was able to walk more freely with the eyes covered, and in a few days more the gait became entirely normal. During her stay at the hospital the girl passed about 75 grams of feces, 3 to 4 times per day. Since every microscopic preparation of less than 1 mg. of feces contained 2 or 3 eggs of *Hymenolepis nana*, an enormous number of parasites must necessarily have been present. Some *Trichuris* eggs were also present. No special anthelmintic treatment was attempted. Cima thought it very likely that the nervous disturbances were to be attributed to the excitation of the intestinal sympathetic plexus from the irritation set up by the heads of the parasites embedded in the mucosa.

Case No. 57 (Cima's Case 67).—Boy, 3 years, from the city, abdominal tuberculosis. This case was a typical one of abdominal tuberculosis, from which death finally occurred. Eggs of *Ascaris*, *Trichuris*, and *Hymenolepis nana* were present in the feces.

In none of the above four cases were Charcot-Robin crystals found in the feces.

Catania, Sicily, 1895 .... 23 cases.

Cases Nos. 58 to 80.—Venuti (1895) (referred to by Massari, 1898, p. 213) observed in the Reale Ospizio di beneficenza di Catania, 23 cases of *Hymenolepis nana* in 214 boys examined. Most of these cases harbored a considerable number of worms, while in 100 boys of the general population belonging to diverse classes and in widely differing conditions of life he could not find a single case. The lack of cleanliness among the inmates, the intimate association of some of those affected with worms, the appearance of subjective disturbances in others after they had been in the institution a certain length of time, ceasing rapidly after the expulsion of the parasites, were circumstances which Venuti considered indicative of the occurrence of a direct contagion of endemic character.

Cologne ?, Germany, between 1892 and 1896................ 1 case.

Case No. 81.—Huber (1896a, p. 573), upon the basis of a personal letter from Leichtenstern, records a case of *Hymenolepis nana* in Germany. A boy 7 years old, suffered 1½ years from nocturnal enuresis, which disappeared after the evacuation of the parasites.

Cologne, Germany, 1894.................................. 1 case.

Case No. 82.—In a table of cases of helminthiasis, Bücklers (1894a) records the case of a girl, 7 years old, in whose feces a few eggs of *Hymenolepis nana* were present. Charcot-Robin crystals were absent. Blood examinations showed eosinophile cells, 7 per cent; polynuclear, 42 per cent; mononuclear, 42 per cent; transition forms, 9 per cent.

Rome, Italy, 1896 .... 1 case.

Case No. 83.—Massari (1896, 1898, p. 212) in 1896 determined the presence of *Hymenolepis nana* in Rome by finding the eggs in the feces of a little girl 7 years of age.

[? Catania, Sicily], Italy .... 2 cases.

Case No. 84.—Galvagno (? date) found numerous *Hymenolepis nana* in one of his little girls (referred to by Massari, 1898, p. 213).

Case No. 85.—Feletti (Massari, 1898, p. 213) found one of his little girls infected with *Hymenolepis nana*.

Cologne and Bonn, Germany, 1897–98 .... 1 case.

Case No. 86.—The case of a little girl 2¼ years old is reported by Röder (1899) from the medical clinic at Bonn.

The child is well nourished, the mucous membranes are perhaps somewhat paler than usual. The bowels are regular, and there is no apparent organic trouble. Until 4 months before, she had lived in Cologne. At 13 months she suffered from intestinal catarrh and cankered mouth, at 18 months passed an *Ascaris*, and at 2 years had measles. After this she became pale, her appetite diminished, she grew dull and drowsy, blue rings appeared under the eyes, and she picked at the nose. Anthelmintics were administered, but no worms were seen.

The patient was brought to the hospital and placed under anthelmintic treatment, August 19, 1897. Three 0.05 gram doses of calomel were given and the next morning, after 80 grams of milk, 2.5 grams of ethereal extract of male fern, followed by a purge of castor oil, were given. In the stool which resulted, numerous eggs of *Ascaris* and eggs of *Hymenolepis nana* (3 to 4 in each preparation), but no worms were found. For several days following, eggs of *Ascaris*, but none of *Hymenolepis*, were present in the feces. On September 1, *Hymenolepis* eggs were again numerous. The next day three 0.05 gram doses of santonin were given an hour apart, followed by castor oil, but neither *Hymenolepis* nor *Ascaris* was found in the passages. *Hymenolepis* eggs were not found again up to the time the child was removed from the hospital on the 9th of September. In December an examination of feces from the child showed numerous *Ascaris* eggs, and an average of one *Hymenolepis* egg in each preparation.

The child was returned to the hospital March 15, 1898. At that time she was in poor physical condition. She was suffering from conjunctivitis, scrofular keratitis, rhinitis, eczema of the scalp, with glandular swellings in the neck, axilla, and groin. Pulse was 120. The feces as before contained eggs of *Ascaris* and *Hymenolepis*. During the afternoon of the 18th two teaspoonfuls of castor oil were administered, which had no effect. The next morning a tapeworm remedy (Bandwurmtritol `Helfenberg), in a dose equivalent to 5 grams extract of male fern, was given, followed in half an hour by two teaspoonfuls of castor oil. Some of the remedy was thrown up, but 4 grams more of the extract (in the same preparation) was given with the oil. Three-quarters of an hour later an enema of 10 grams of glycerin was also given. In the stools which followed no worms, but only eggs of *Ascaris* and *Hymenolepis*, were to be found.

Nine months later, in December, the stools were examined and found entirely free from eggs.

Bearing in mind the possibility of infection from infested rats or mice, Röder examined two of the houses at Cologne in which the patient had lived, and found them free from rats. Several examples of mice which were caught there contained no worms. The new abattoir of Cologne was also free from rats.

Moscow, Russia, 1900

- - - - - - - - - - - - - - - - - -1 case.

Case No. 87.—A curious case, possibly of *Hymenolepis nana*, has been reported by PREDTETSCHENSKY (1900) from the propaedeutic clinic of Moscow University.

The patient was a female, 33 years old, wife of an officer, and had never been in the Tropics. She was suffering from chyluria of some 16 years standing. In one of the numerous microscopic preparations which were made of the urine sediment there were found about 10 specimens of what appeared to be cestode eggs, resembling in size and structure those of *Hymenolepis nana*. These bodies were round with a laminated capsule and were so transparent that the six hooks, characteristic of cestode embryos, were clearly distinguishable under an immersion lens. In size the eggs measured 20 to 25 μ. In no other preparation were the eggs seen. Accidental contamination seemed, *a priori*, very evident, and since the vessel in which the urine had been collected had been carefully cleaned with boiled water, suspicion was directed toward the feces of the patient, which were examined several times, but always without the discovery of any tapeworm eggs. The riddle therefore remained unsolved. The remarkable coincidence of the eggs of the rare parasite *H. nana*, and the rare disease, non-tropical chyluria, was commented upon by the author. He further cites the instance of a case of chyluria in Madagascar, observed by Doctor Ollivier, in the analysis of which M. Bordier is said to have demonstrated the presence of *Davainea madagascariensis* in the kidneys, and considers it possible that *Hymenolepis nana* may also settle in the urinary organs and give rise to a true chyluria.

There are a number of possibilities in connection with this case: First, that the eggs were passed in the urine; second, that they came from the feces of the patient; third, that they were from the feces of another person, or that they were eggs resembling the eggs of *Hymenolepis nana* from a tapeworm of some animal, bird, rat., etc., and came by some fortuitous circumstance into the preparation.

There are two objections to the first possibility, namely, the unusual occurrence of cestode eggs in the urine, and the fact that they were found in but one preparation, so that this possibility remains very improbable, notwithstanding the attendant chyluria. The second possibility is quite probable, since the eggs of *Hymenolepis nana* not only are often difficult to find, but frequently disappear spontaneously from the feces and later recur again, so that even a large number of examinations might fail to disclose the presence of the parasite. Even the most extreme care in technique is insufficient to entirely exclude the last-named possibility.

The authenticity of this case is therefore extremely doubtful.

ASIA.

Siam, 1892 .... 1 case.

Case No. 88.—In September, 1892, RASCH (1894) was consulted by a native girl, 7 years of age. The patient had suffered for a long time with sleeplessness. There was no organic trouble. She was constipated, so that cathartics were frequently necessary. Vomiting was of common occurrence, especially in the morning, which was not due to overeating, as she had but little appetite. The stools were usually mixed with copious quantities of mucus. Temperature, pulse, heart, lungs, abdomen were normal. The patient appeared somewhat pale and anemic, and blue rings were often present under the eyes. Her general physical condition was fairly good. An examination of her feces showed the eggs of *Hymenolepis nana*, larval nematodes [? *Strongyloides stercoralis*] and a female *Oxyuris vermicularis*. After treatment with male fern, 50 to 80 specimens of *Hymenolepis nana* were isolated from the stool.

Tokyo, Japan, 1895 .... 2 cases.

Cases Nos. 89 and 90.—MIURA & YAMAZAKI (1897) report two cases from Japan.

The first case was that of a boy of 5 years, who had been received in 1893 at the poorhouse with his mother. In June, 1895, he became ill of a fever, with enlargement of the liver and spleen. The feces contained eggs of *Oxyuris*, *Trichuris*, and *Hymenolepis*, but the patient showed no reflex nervous symptoms which might be traced to helminthiasis. When the fever had improved somewhat the boy was dosed with a decoction of pomegranate, followed by castor oil. Many *Oxyuris* were passed, but no *Hymenolepis*. Two days later, besides the pomegranate decoction and oil, male fern was also administered. A large number of *Hymenolepis* were passed, of which over 150 were isolated. After three weeks the eggs again appeared in the feces, and 15 more tapeworms were passed after doses of male fern and salts.

Case No. 90.—The second case, also observed in 1895, was a foundling, girl, aged 5 years, who had entered the poorhouse the year before. After a while she became thin and anemic, suffered from irregular attacks of remittent fever and diarrhea. Examination of the thoracic and abdominal organs gave mostly negative results; the abdomen was rather sensitive to pressure. The eggs of *Trichuris*, *Oxyuris*, *Ascaris*, *Agchylostoma*, and *Hymenolepis* were found in the feces. Hookworm eggs were seen only after 60 preparations were examined and those of *Hymenolepis* only after 70 preparations. After treatment with pomegranate and male fern, two specimens of *Hymenolepis nana* were passed.

AMERICA.[a]

Philadelphia, Pa., 1872 .... 1 case.

Case No. 91.—SPOONER (1873a, b), on September 3, 1872, presented to the College of Physicians of Philadelphia some specimens of *Hymenolepis nana* from the first case observed in America. They were passed by a young man who had symptoms of general debility, occasional colicky attacks, diarrhea, severe frontal headache, disturbance of vision, with slight febrile exacerbations, occurring at irregular intervals during the two weeks preceding the above date. Up to the time of the report no marked emaciation had occurred; the appetite was less fitful, and the vision more perfect, but the pain in the head had not much abated.

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[a] See also footnote, p. 7.

Buenos Ayres, Argentina, 1886 ---------------------------? 1 case.

Case No. 92.—According to O. Wernicke (1890, p. 351), Dr. Roberto Wernicke, in 1886, observed in the feces of a little girl cestode eggs, which he was unable to identify as belonging to any species known to him. He administered a vermifuge, but did not succeed in finding any worms. After seeing the eggs from O. Wernicke's case (1890), Dr. R. Wernicke expressed the opinion that the eggs found by him in 1886 were of the same species.

Buenos Ayres, Argentina, 1890 ---------------------------1 case.

Case No. 93.—Wernicke (1890) found 30 to 40 specimens of *Hymenolepis nana* in the intestine, at the autopsy of an Argentine sailor, aged 28 years, who had died of pulmonary tuberculosis. This case was also reported and the specific determination confirmed by Blanchard (1891a).

São Paulo, Brazil, 1893–1894 ---------------------------2 cases.

Lutz (1894) reports two cases of *Hymenolepis nana*, also a case of *Hymenolepis diminuta*. (See p. 98.)

Case No. 94.—The first case was that of a 2½-year-old girl who had shown symptoms of nervous and intestinal troubles for about a year. Several times she suffered from irregular attacks of fever, and showed other symptoms common to the teething period. Ascarids were passed on several occasions. During one of the attacks of fever the feces were examined; encysted flagellates and eggs of *Trichuris* and of *Hymenolepis nana* were found. After the fever had subsided, a treatment with ethereal extract of male fern resulted negatively. A second attempt was made with freshly obtained extract in three doses of 0.3 gram each at intervals of two hours, and in the stool after the first dose 5 strobilae, without recognizable heads, were obtained. There was a slight improvement for a while, but the former symptoms of abdominal pain, diarrhea, restless sleep, and pained expression of countenance, soon returned. Male fern was again administered in a 3-gram dose, and about 100 *Hymenolepis*, 15 of them with heads, and 2 female *Trichuris* were expelled. Two weeks later the child was much improved, but not entirely well.

Case No. 95.—The second case was a 4-year-old girl, born in São Paulo, of foreign parents. She had suffered for two years with continual diarrhea and intermittent attacks of fever. Carefully regulated diet and treatment in Europe, had had no ameliorating effect. There were symptoms of perverted appetite, eating of plaster from the wall, etc., while the nervous symptoms were little pronounced. Contrary to what one would expect from the length of time the trouble had lasted, the nutrition had not suffered to an appreciable extent, a circumstance due perhaps to the care which the girl had received. After the discovery of eggs of *Hymenolepis nana* in the feces 4 grams of ethereal extract of male fern in emulsion were administered, and two passages containing an enormous number of worms occurred. In an incomplete enumeration, over 2,000 individuals were counted, of which about 10 per cent had heads. Little chains of ripe segments were also common. About three weeks later, the extract was again given, in a dose of 2.5 grams, and 25 worms were passed. All symptoms of the former trouble disappeared, and while previously the diarrhea had persisted in spite of all carefulness in diet, the stools became normal and so remained, although the girl now ate anything she pleased.

Galveston, Tex., 1902 ---------------------------1 case.

Case No. 96.—Moore (1903)[a] has reported a case of *H. nana* from Texas, in a preliminary note read recently before the University of Texas Medical Club.

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[a] See also Moore (1904).

"On August 2, 1902, T. O. C., a section foreman of the Galveston, Houston and Henderson Railway, presented himself, complaining of a severe diarrhea and cramps in the abdomen. His history was as follows:

"Family history good. No previous sickness of any kind. Present illness began in the early part of June, 1902, with headaches and a slight fever. About July 28, he was taken with a severe diarrhea and much pain in the bowels. He had from ten to twenty stools per day. Passed mucus and blood in the motions. Suffered great weakness.

"He was given a diarrhea mixture and asked to return in case he was not relieved. He came back on August 4, stating that he was no better."

Amebic dysentery or the presence of some intestinal worm having been suspected, an examination of the feces was made which resulted in the discovery of the eggs of *H. nana*, and after the administration of an anthelmintic, a number of the worms themselves were passed. The effect upon the symptoms of the expulsion of the worms is not stated in Doctor Moore's paper. The specific determination of the parasites in this case was confirmed in this laboratory.

Charleston, S. C., 1902 ....1 case.

Case No. 97.—Stiles (1903a, p. 40), in October, 1902, while examining some of the students of the Charleston, S. C., Medical School, found that the stools of one of them (Mr. T.) contained numerous eggs of *Hymenolepis nana*. The young man was 22 years of age, and came from the country. Later examinations showed that he was also infected with *Uncinaria americana*. The symptoms in this case, from what information I have, seem to have been only very slight. The patient complained of a certain degree of nervousness. Dr. J. L. Dawson, who has expressed the intention of publishing a full clinical history of this case, after the discovery of the eggs, placed the patient upon anthelmintic treatment. In a letter to Doctor Stiles he states that hundreds of the worms were passed. Doctor Dawson kindly furnished this laboratory with specimens from this case, which have been entered in the Helminthological Collection (No. 9402) of the United States Public Health and Marine-Hospital Service.

Macon, Ga., 1902 ....3 cases.

In November, 1902, while examining 39 children in two orphan asylums at Macon, Ga., Stiles (1903a, p. 41, 42) found 3 cases of infection with *H. nana*. The patients were as follows:

Case No. 98.—R. J., female, 11 years old, from Lumber City, Telfair County, Ga.; a case of light infection.

Case No. 99.—M. N., female, 13 years old, from Taylor County, Ga.; a case of very heavy infection.

Case No. 100.—O. H., male, 16 years old, from Wright, Wilcox County, Ga.; a case of light infection.

We have no data as to the symptomatology of these cases, nor any information with regard to the results of treatment, if such were tried.

Washington,[a] D. C., 1903..............................6 cases.

In a series of about 2,000 fecal examinations of patients at the Government Hospital for Insane at Washington, made during 1902–1903 in this laboratory, the eggs of *Hymenolepis nana* were encountered six times.

Case No. 101.—The patient in this case was a woman (white); aged, about 60; an inmate of the hospital for a good many years. Shortly after the examination, when the eggs were discovered, the patient was sick for several days. We have had no information as to the exact nature of the ailment. Specimens of several stools taken during this time were liquid in character and no eggs were to be found, nor were any eggs seen in preparations of the stools of this patient examined on one or two occasions after her recovery.

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[a] See also footnote, p. 7.

Case No. 102 (Gov. Hosp. case No. 9901).—I. L., colored; age, 32; born in Virginia; admitted to the hospital in May, 1896, suffering with chronic dementia which had lasted one year; supposed cause, masturbation. He has been an inmate of W. L. building continuously since 1900, and of ward 3 of this building since April 11, 1903. He is said to be in good physical condition and works in the power house. In July, 1900, he was sick for a few days and lost considerable flesh; but, after treatment for three days with an ague mixture, improved and was soon back at work. In October, 1901, he was affected with a skin disease resembling itch, which disappeared after local treatment with iodine. Eggs of whipworm (*Trichuris trichiura*) and of *Hymenolepis nana* were present in his feces in May, 1903.

Case No. 103 (Gov. Hosp. case No. 9376).—E. Q., colored; indigent; age, 32; born in District of Columbia; admitted to hospital November, 1894, with congenital imbecility. He has been an inmate of W. L. building continuously since August, 1899, and of ward 3 since February, 1902. His weight has ranged from 222 to 232. He has been detected at various times masturbating, and during these periods he has been more demented. Physically he remains in good health. Eggs of *H. nana* were seen in the feces in 5 out of 10 preparations examined; whipworm eggs were also present.

Case No. 104 (Gov. Hosp. case No. 12804).—H. J., colored; sergeant (retired), U. S. Army; cook; age, 51; admited to hospital from Army General Hospital, Presidio, Cal., November, 1901, with delusional melancholia of six months' duration, supposed cause organic brain disease. He has been an inmate of ward 3 of W. L. building, continuously since March, 1902. At a physical examination in November, 1901, he was found to be fairly well developed; his abdomen was tense, rounded, and tympanitic; his bowels were constipated. Muscular movements were slow and weak; coordination was fair. Muscle reflexes were diminished, tendon reflexes normal. He suffered at times with vertigo. Opacity of both crystalline lenses was present. His mental symptoms were false perception, poor memory, false ideation, poor reasoning and judgment, delusions and auditory hallucinations. In habits he is fairly cleanly. An examination of his urine, November 11, 1901, showed a slight hematuria, which had entirely disappeared ten days later. He suffered from malaria (tertian type) for a few days in November, 1901, but recovered promply after treatment. In May, 1903, the eggs of *H. nana* were found in the feces in 7 out of 10 preparations examined.

Case No. 105 (Gov. Hosp. case No. 10953).—C. G., colored; indigent; age 47; born in Maryland; admitted to hospital October, 1898, with chronic mania of 20 years' duration; supposed cause prison life. He has been an inmate of ward 3, W. L. building continuously since February 1901. His health is reported good and appetite excellent. This case was a heavy infection; numerous eggs were found in the feces, in all of 10 preparations examined, May, 1903; whipworm eggs were also present.

Case No. 106 (Gov. Hosp. case No. 8857).—J. S., colored; indigent; age 40; born in Florida; admitted to hospital July, 1893, with acute melancholia of three months' duration; supposed cause, masturbation. He has been an inmate of ward 3, W. L. building, continuously since February, 1901. In the fall of 1901 he suffered for some time with a skin disease resembling itch, localized in the neighborhood of the genital organs. The eruption became better, and finally disappeared after local treatment with iodine. He is said to be in good health, with good appetite, sleeps well, works in the vineyard. In May, 1903, fecal examination showed eggs of *H. nana* in 7 out of 10 preparations. Eggs of *Trichuris* were also present.

It is a noteworthy circumstance that of the six cases of *H. nana* at the insane hospital, five were found among colored patients, all inmates of the same building and the same ward. This fact fits in very well with the assumption that a direct infection occurs from one person to another, and is evidence similar to that brought forward by Venuti (see p. 55).

ANALYSIS OF CASES AND DISCUSSION OF SYMPTOMS.

AGE AND SEX OF INDIVIDUALS AFFECTED.

In the 106 cases of *H. nana*, at least 60, and probably 70, of the individuals affected were males; 30 were females, while in the reports of the remaining 6 cases the sex is not indicated. Sixteen and probably 18 were over 20 years of age, 2 at least being over 50; 84 were younger than 20 years; in 4 cases no reference is made to age. Between 1 and 5 years there were 9 cases; 5 and 10 years, 24 cases; 10 and 15 years, 5 cases; 15 and 20 years, 5 cases; 41 other cases were reported simply as children.

According to these figures *Hymenolepis nana* is much more common among children than among adults, and males are more often infected than females. Five to 10 years seems to be the age most frequently affected. The very large percentages of males and children may be due in some degree to the fact that in the more heavily infected regions investigations have been made more especially among children than among adults, and among males than among females.

GENERAL ENVIRONMENT AND SOCIAL POSITION OF INFECTED INDIVIDUALS.

With regard to the social position and general environment of the individuals affected, it is to be noticed, in the first place, that 32 of the cases were in orphan asylums or poorhouses, 27 being in the asylum at Catania, Sicily; 3 in two asylums at Macon, Ga., and 2 in a poorhouse at Tokyo, Japan; and 6 cases were in an insane asylum in the District of Columbia. Of the remaining cases, 6 or 8 may be said to belong among the well-to-do classes. Grassi, also (Grassi & Rovelli, 1892a), as already stated, refers to an indefinite number of cases which occurred among the children of well-to-do families. It is only certain that the patients in about 20 of the 62 cases remaining were poor, but it is probable, judging from various circumstances related in connection with individual cases, that the majority were from the poorer classes.

The conclusion does not, therefore, seem unjustified that the children of the poor are more liable to infection, and children gathered together in institutions seem especially likely to show a heavy percentage of infection; the worm, in fact, seems to be particularly common in orphan asylums. Among adults, also, institutional life seems to favor infection (cases Nos. 101 to 106).

There are about 47 cases which can be assigned to the city as against 15 to the country (including the cases from the asylums [except the Macon cases] among the former). Investigations have been made, however, mostly among city inhabitants.

PREVALENCE OF INFECTION.

At many of the hospitals in Germany a large number of examinations for parasites are made every year, but so far only 4 cases of *Hymenolepis nana* have been reported from that country. Mertens (1892, p. 1136) states that 300 to 400 patients, mostly adult however, are examined yearly at the Cologne Hospital, and that formerly the eggs of *Hymenolepis nana* had never been found. After the discovery of the eggs of the parasite in the feces of a child who had entered the hospital, 100 other children, at that time in the hospital, were carefully examined for evidences of parasitic infection. Although 14 cases of helminthiasis were found, *H. nana* was not present.

In Italy the parasite is decidedly common. Calandruccio estimates that in Sicily 10 per cent of the children are affected.

Venuti (1895), according to Massari (1898), determined the ratio of infection among 214 boys in the orphan asylum at Catania to be over 10 per cent (23 cases), while among 100 boys from various classes of the general population he was unable to find a single case.

Out of about 2,000 fecal examinations made at this laboratory during 1902–1903, of adult patients at the Government Hospital for the Insane, Washington, D. C., the eggs of this parasite were encountered 6 times.

Stiles (1903a, pp. 41, 42), in about 160 fecal examinations made during a recent trip through the South Atlantic States in connection with an investigation of uncinariasis, found the eggs of *Hymenolepis nana* 4 times, once in the examinations of 15 medical students, and 3 times among 39 children in 2 orphan asylums.

GEOGRAPHIC DISTRIBUTION OF *Hymenolepis nana*.

Geographically the cases of *Hymenolepis nana* in man are distributed as follows:

Egypt, 3 cases; England, 1 case; Sicily, 48 cases; Italy, exclusive of Sicily, 27 cases; Russia, 2 cases and 1 doubtful case; Germany, 4 cases; Servia, 1 case; Siam, 1 case; Japan, 2 cases; Pennsylvania, 1 case; District of Columbia, 6 cases; South Carolina, 1 case; Georgia, 3 cases; Texas, 1 case; Brazil, 2 cases; Argentine, 1 case and 1 doubtful.

The worm has been reported from rats or mice in the following places:

Austria (Stossich, 1898, p. 104); Denmark (Krabbe, 1865, p. 39); Germany (Grassi, 1887h, p. 312; Linstow, 1896a, p. 579; Moniez, 1888); France (Dujardin, 1845a, Moniez, 1888); Italy, including Sicily (Grassi, Calandruccio); United States (specimens in the B. A. I. Coll., U. S. Dept. of Agr., collected in Maryland and the District of Columbia); Brazil (Lutz, 1894).

The figures seem to show that a rather warm and moist climate is especially favorable to the development of cases of *Hymenolepis nana*. As would be expected upon the assumption that the forms in man and in the rat are the same species, the statistics indicate a certain degree of coincidence in the occurrence and frequency of *H. nana* in man and in the rat for any locality, modified, it is true, by other factors, such as the hygienic conditions of the community, the habits and customs (personal hygiene, character of food) of the inhabitants, etc. In general its distribution may be considered cosmopolitan, like that of its hosts, but more restricted by certain conditions, among which are, perhaps, climate and moisture.

SITUATION IN THE INTESTINE.

The results of a number of autopsies show that the portion of the intestine infested is a greater or less part of the ileum, especially its upper two-thirds or three-fourths.

NUMBER OF SPECIMENS PRESENT.

The number of specimens of *H. nana* present in the various cases has ranged from 1 to several thousand. In one case, 1 specimen only was found at the autopsy; 2 specimens were passed in one case; 20 were present in one case; 30 to 40, 1 case; 50, 1 case; 50 to 80, 1 case; between 100 and 200, 2 cases; from 200 to 400, 4 cases; 600 to 700, 1 case; 1,000, 1 case; 1,400, 1 case; 2,000, 1 case; in 5 cases in which no figures were given there were said to be few; in 7 cases a very large number or several thousand.

OTHER PARASITES PRESENT.

Multiple infection occurred in 27 cases. *Oxyuris vermicularis* was present 12 times, *Trichuris trichiura* 19 times, *Ascaris lumbricoides* 16 times, *Agchylostoma duodenale* 5 times, *Uncinaria americana* once, *Tænia saginata* 2 times, *Tænia solium* once, encysted flagellates once, larval nematodes [? *Strongyloides stercoralis*] once. They were associated together with *H. nana* as follows:

Trichuris, 6 cases; *Ascaris*, 3 cases; *Oxyuris*, 2 cases; *Agchylostoma duodenale*, 1 case; *Uncinaria americana*, 1 case; *Tænia saginata*, 2 cases; *Oxyuris* and *Trichuris*, 1 case; *Oxyuris* and *Tænia solium*, 1 case; *Oxyuris* and larval nematodes [? *Strongyloides*], 1 case; *Oxyuris*, *Trichuris*, and *Ascaris*, 6 cases; *Trichuris* and *Ascaris*, 2 cases; *Trichuris*, *Ascaris*, and encysted flagellates, 1 case; *Trichuris*, *Ascaris*, and *Agchylostoma duodenale*, 2 cases; *Ascaris* and *Agchylostoma duodenale*, 1 case; *Oxyuris*, *Trichuris*, *Ascaris*, and *Agchylostoma duodenale*, 1 case.

DURATION OF INFECTION.

The duration of infection as determined by the actual observation of eggs in the feces after the time they were first seen was 2 months in one case (No. 43), 6 months in 3 cases (Nos. 36, 45, 53), 7 months in 2 cases (Nos. 48, 86), 1 year to 2 years, 3 cases (Nos. 4, 47, 49), 2½ years, 1 case (No. 38).

As determined also by the length of time the symptoms existed, which were cured or improved by anthelmintic treatment: 3 months, 1 case (No. 42); 7 months, 1 case (No. 41); 1 to 2 years, 7 cases (Nos. 37, 43, 44, 49, 81, 94, 95); 5½ years, 1 case (No. 38). In 1 case (No. 36) the symptoms disappeared spontaneously after lasting 6 months, reappeared after a lapse of 1½ years, then disappeared again after anthelmintic treatment, but recurred with the reappearance of eggs in the feces.

In cases which were not treated the symptoms lasted 3 years, ending in death in 1 case (No. 9); and for 2 years in another case (No. 55); in a third case (No. 48) symptoms, which may have been caused by the presence of *H. nana*, were exhibited for nearly 6 years.

GENERAL SYMPTOMATOLOGY OF INTESTINAL HELMINTHIASIS.

Before taking up the analysis of symptoms exhibited in cases of *Hymenolepis nana*, it is considered advisable to review shortly the symptomatology of other intestinal worms, especially tapeworms. Generally speaking, the injurious effects of intestinal worms may be looked upon as due to one or more of the following causes, namely, the mechanical obstruction occasioned by their presence, the irritation to the wall of the intestine, the influence of this irritation upon the nervous system, the loss to the host of nutritive materials which go to supply the parasites, and finally, the elminination by the parasites, of toxic principles which are absorbed by the host.

In discussing the phenomena produced by worms, Davaine (1860a, pp. 48 et seq.), the eminent French helminthologist, says in part essentially as follows:

> The presence of worms in the intestine does not always result in appreciable phenomena; it is compatible with the most perfect health; but is frequently manifest by variable phenomena of a local and often of a sympathetic nature.
>
> The local phenomena consist of derangements of the intestinal functions, abdominal pains, anal pruritus, and occasionally anatomical lesions of some importance.
>
> Any organ may be affected reflexly by intestinal worms; false perception of odors, dilation of the pupil, permanent or transitory amaurosis, abnormal sensitiveness of hearing, perversion of taste, itching and formication of the skin, bear witness to the sympathetic action of the parasites upon the senses; from another side, somnolence, vertigo, frightful dreams, spasms, vague pains, cough, dyspnea, cardiac palpitations, irregularities of pulse, insatiable hunger or anorexia, salivation, quality of the urine,

emaciation, witness equally their action upon the nervous system, upon the organs of respiration, upon the circulation, upon the digestion, upon the secretions, and upon the nutrition. While the sympathetic effect of intestinal worms upon organs more or less remote, and the functional disorders which they occasion can not be denied, one ought not, on the other hand, to display the ignorance and prejudices characteristic of a former epoch, by accepting without scrutiny all the accounts which have been transmitted to us, even when coming from most eminent men. Although very grave symptoms are sometimes unquestionably determined by intestinal parasites, doubt and caution should compel us to suspend judgment in very many cases where the presence of worms and illness may only be a simple coincidence.

The absence or appearance of functional troubles, their frequency or variable intensity is not explained by differences in the nature of intestinal worms. *Tænia*, *Bothriocephalus*, *Ascaris*, or *Oxyuris* may all give rise to similar phenomena. The number or the size of these entozoa is undoubtedly not without influence upon the development of pathologic phenomena; their presence seems to be less easily supported in the stomach than in the intestine; but in certain cases, neither the species nor their number or size, nor the part of the intestine which they occupy, accounts for the variations or the intensity of the symptoms, which often depend upon bodily peculiarities and the degree of susceptibility of the individual affected; in fact, women experience ordinarily the most severe derangement of health, and feeble and nervous individuals are also more affected than those in better condition. (Translation.)

Davaine says further (1860a, pp. 103 et seq., in part):

The principal symptons of *Tænia* are giddiness, humming in the ears, disorders of vision, nasal and anal pruritus, salivation, disorders of appetite and digestion, colic, pains in the epigastrium and other regions of the abdomen, cardiac palpitation, syncope, sensations of a ball or weight in the abdomen rolling about and following the movements of the body, pains and lassitude in the limbs, and emaciation.

The abdominal pains caused by *Tænia* may be of the nature of colic or of gastralgia; frequently their character is difficult to appreciate. They are referred to different parts of the abdomen, are of varying severity, sometimes lively and intermittent, and are ordinarily not accompanied nor followed by diarrhea. They constitute the most common symptom of *Tænia*.

Anal pruritus is also a very common phenomenon. While, in some cases, it may, like nasal pruritus, be attributed to a sympathetic influence, it is usually due to irritation of the lining of the lower part of the intestine, produced by the contact and movements of detached segments. Itching of the nose is less frequent, but it is rare that an individual affected with *Tænia* does not suffer from either nasal or anal pruritus.

The appetite is often augmented, sometimes insatiable; at other times it is lacking or subject to alternate augmentation and diminution.

There exist very often among persons affected with *Tænia* a general debility, lassitude, cramps, and pains in the extremities, sufficiently severe to interfere with the usual occupation.

Emaciation is very common when the infection is of long standing. Sometimes it is accompanied with bloating and distension of the abdomen.

The greater part of these phenomena do not have very serious effects upon the individuals affected; but it is different with certain convulsive symptoms which develop under the influence of *Tænia*. These consist in attacks of more or less similar nature, presenting the characteristics of epilepsy, hysteria, chorea, etc., in some cases very intense and severe. These functional disorders are the most frequent among those brought about by the presence of *Tænia* and disappear with the expulsion of the parasite. This coincidence and the fact that the symptoms do not recur leaves no doubt as to their cause. (Translation.)

Numerous cases are referred to by Davaine in which epileptiform attacks, chorea, tremors, paralysis, cough, bulimia, perversions of sense, weakening of the mental faculties, or deafness occurred, and in which the expulsion of tapeworms marked the disappearance of the symptoms. He also speaks of momentary loss of speech, loss of memory, persistent insomnia, frequent epistaxis, repeated vomiting, disorders of the sexual functions, etc., as occasional symptoms determined by the presence of tapeworm.

Seeger (1852, p. 80) gives the following list of symptoms, with their frequency, considered by him to be of diagnostic value and gathered from the accounts of 100 selected cases of large tapeworms:

> Acute colic, 17 per cent; abdominal pains of various sorts, 42 per cent; vertigo, 15 per cent; periodical and habitual headache, usually unilateral, 19 per cent; irregular appetite or bulimia, 31 per cent; frequent nausea, with vomiting or feeling of faintness, 49 per cent; peculiar sensations of movements in the abdomen, 16 per cent; vague pains in different parts of the body, 11 per cent; digestive troubles and irregularities of the bowels, 33 per cent; failure and derangements of speech and special senses, 15 per cent; cerebro-spinal symptoms, especially local or general convulsions (epilepsy, hysteria, melancholia, hypochondria, clonic convulsions; dyspnea, convulsive cough, etc.), 68 per cent.

Hirsch (1879a), in a statistical study of 100 cases of infection with large tapeworms observed by Doctor Mosler in his practice at Giessen and Greifswald, Germany, has given the relative frequency of such symptoms as were considered due to the presence of the parasites.

Of gastro-intestinal phenomena, colic appeared in 14 cases without apparent cause. Abdominal pains of various kinds were present in numerous cases. The prevailing gastric symptoms were, matitudinal vomiting, 1 case; pyrosis, 8 cases; unpleasant eructations after eating, 5 cases; nausea, 13 cases; frequent vomiting, 12 cases; loss of appetite, 6 cases; bulimia, 10 cases, and various sorts of capricious appetites in other cases.

Constipation occurred in 5 cases, diarrhea in 6 cases, and the bowels were irregular in 3 cases.

Epileptiform convulsions, cured after the expulsion of a tapeworm, occurred in one case, and severe manifestations of a convulsive nature were present in 2 cases. Vertigo was complained of in 16 cases. Loss of consciousness occured in 2 cases. Headache was present in 14 cases. Flickering vision and a sensation of blackness before the eyes were symptoms in 2 cases, and in a third case vision was diminished in one eye. Cardiac palpitation occurred in 6 cases. Salivation was present in 6 cases, anal pruritus in 19 cases, and itching of the nose in 12 cases. Disturbed sleep was common; in 1 case the sleep was much troubled, there was complete insomnia in 1 case, and abnormal sleepiness in a third case.

Of symptoms depending upon general organic disturbances, among others, the following were noticed:

Feeling of weakness, especially in the knees, 2 cases; gradual loss of strength, 4 cases; general and continued weariness, 4 cases; anemia, 1 case; chlorosis, 1 case; paleness without appreciable cause except the presence of tapeworm, 4 cases.

Two cases were marked by icterus, apparently due to tæniasis.

In the actual cases of tapeworm, about 130 in number (the remainder being delusion cases) among the 180 cases observed by Cobbold (1883a), besides gastro-intestinal symptoms, evidences of deranged nutrition, and minor nervous symptoms of common occurrence, severe nervous phenomena appeared several times. Three well-marked cases of chorea occurred in boys (Cobbold's cases X, XI, CXVI) cured after the expulsion of tapeworms. A boy 2½ years old (Case LXXVII) suffering from convulsive fits rapidly improved in health after expulsion of a tapeworm. A little girl (Case CLV) also showed rather severe nervous symptoms. Among adults, partial hemiplegia occurred in 1 case (XXXV), with spectral illusions, and spasms of the muscles of one side of the face, which disappeared after expulsion of tapeworm. Partial reflex paraplegia was present in 1 case (XXXIX) with frequent vertigo and loss of consciousness; after expulsion of tapeworm the worst symptoms disappeared. Locomotor ataxia of upper limbs, with other grave symptoms, 1 case (XXV); locomotor ataxia of lower limbs and muscular twitchings, 1 case (LVIII); partial locomotor ataxia with severe symptoms, 1 case (LXIV). Paraplegia, which almost disappeared after the tapeworm was expelled, 1 case (XCV). Frequent syncope and mental depression, 1 case (XLVIII). There were several other cases in which severe nervous affections occurred, apparently, however, due to other causes, since anthelmintic treatment was without effect upon the symptoms.

It should be noted that most of Cobbold's cases were male adults; Hirsch's cases also were mostly among adults, only 11 patients out of the 100 being under 21 years of age, and only 3 under 10 years, and males were more numerous than females, 74 of the former to 26 of the latter.

Numerous other statistics with regard to tapeworm infection might be quoted, but those given are sufficient to show that severe symptoms are often associated with the presence of the larger tapeworms (especially *Tænia saginata* and *T. solium*), the expulsion of which is followed by the disappearance of symptoms.

SYMPTOMATOLOGY AND PATHOLOGY OF HELMINTHIASIS WITH HYMENOLEPIS NANA.

Owing to the small size of *Hymenolepis nana* one might be led to assume at once that its presence in the human intestine could bring about no harmful effects of importance. On the other hand, a glance at the evidence furnished by the various cases of *H. nana* on record shows that severe symptoms are of frequent occurrence. As an additional support of the fact that the size of a tapeworm is no index of the amount of damage it may do, a number of instances might be given in which small tapeworms are occasionally even a serious menace to life. In such instances, however, it is usually the case that the number of worms present is so great that mechanical obstruction alone, not to speak of the loss of nutrition to the host, is sufficient to explain the severe results; or it may happen, as occurs in the case of a certain comparatively small tapeworm of the chicken, that the parasites bore deeply into the submucosa and almost or entirely penetrate the intestinal wall, and in this way give rise to very serious effects.

In considering the manner in which *Hymenolepis nana* affects its host, the question of mechanical obstruction may be left out of account, unless the parasite is present in overwhelming numbers when it would be of importance.

Since each worm has a separate point of attachment to the intestine, it is likely that considerable irritation will result if many are present. The rather extensive movements of the larger tapeworms while extending or contracting themselves give rise to a certain amount of irritation, but in the case of *H. nana*, it does not, *a priori*, seem probable that its movements would have much of an irritating effect, unless the worm were present in very large numbers. The assumption that more or less irritation of the intestine is caused by the presence of *H. nana* is supported by the fact that diarrhea and other intestinal derangements, and various reflex symptoms commonly attributed to intestinal irritation, occur frequently. As to the extent of the local effects of the parasite under discussion our knowledge is limited. Although some evidence has been adduced, intended to show that pathological changes occur which are of considerable importance, the balance of evidence seems to indicate that organic changes of the intestine, if occurring at all, are very slight.

Innes (1898) speaks of bloody extravasations found on the mucosa of the ileum which he considers might possibly have marked the points of attachment of the tapeworms (Case No. 3).

According to Grassi (1887d) the worms were found to have bored deeply into the mucosa, and to have caused considerable alteration, but the nature of the change is not specified.

At the post-mortem examination of a case (No. 9) of *Hymenolepis nana*, in which 400 specimens were found in the ileum, Visconti & Segré (1886) noticed that the mucosa throughout the small intestine was tumefied, hyperemic, and covered with a thick layer of grayish mucus, through which the worms were scattered. The greater part of the solitary follicles were tumefied. Microscopic examination of a portion of the ileum showed the mucosa swollen and richly infiltrated with lymphoid cells. The connective tissue of the submucosa was sclerosed and thickened.

Mingazzini (1899, pp. 598–599, 603) has recently made some observations upon the mode of attachment of *Hymenolepis nana* to the intestine of the rat, which are of interest in this connection. He found that the rostellum in the living state, when the worm is attached to the intestine, is always extruded, and penetrates deeply into the lumen of a gland of Lieberkühn; it may reach as far as the bottom. Only a very slight alteration is produced in the epithelium of the gland, except at the point where the surface of the rostellum and the epithelium are in contact. The hooks on the anterior part of the rostellum penetrate only the epithelial cells, frequently producing some alteration in their shape and contents and occasionally entirely destroying them over a very small area. At the points where the suckers and the epithelium are in contact there are sometimes found little elevations in the latter, corresponding to the cavities of the suckers. Grassi and Calandruccio, after examining the intestines of rats infected with *H. nana*, asserted that at the point of attachment there seemed to be an abnormal number of leucocytes in the connective tissue. Mingazzini, however, found, upon examining the same preparation used by these authors, that the connective tissue of the tunica propria in the region of the point of attachment of the worm was entirely normal as to the number of leucocytes. If *H. nana* acts the same in the human intestine as in that of the rat, it is not possible, Mingazzini believes, to attribute to this cestode the very grave and extensive anatomical changes in the mucosa of the human intestine, which were noticed by Visconti and Segré, and Grassi. The fact that in the great majority of cases of *H. nana* reported, the individuals affected exhibit no phenomena of disturbance, is also considered by Mingazzini an argument against the occurrence of anatomical changes of importance. He believes it is therefore justifiable to consider that the lesions referred to which have been noticed in the human intestine are pathological conditions concomitant with, rather than due to, the presence of the parasite. The nervous phenomena, he adds finally, which sometimes appear in children infected with *H. nana*, and are cured by the elimination of the parasite, are perhaps due to a toxin which, while not altering the structure of the intestine, acts upon the central nervous system.

The toxic effects of intestinal parasites upon their hosts is a question with regard to which little is known, but sufficient work has been done to show that in some instances parasites elaborate substances which are distinctly poisonous when absorbed. In a review of the results of various investigators bearing upon this point, Linstow (1896b, p. 189) expresses the following opinion:

> The helminths eliminate a poisonous substance, a toxin or a leucomain, as is the case with the pathogenic micro-organisms and, as in the latter case, it is not the me-

chanical disturbance produced by their presence in the human body, but the toxin, which produces illness, and may cause death. (Translation.)

Vaullegeard (1901) states that the products soluble in water obtained by him from a number of different cestodes contain two sorts of substances, one soluble in alcohol and the other precipitated by it. While no experiments were made with *H. nana*, in the case of *Bothriocephalus punctatus* he was able to demonstrate that the substance soluble in alcohol contained an alkaloid very similar to curarin, while in the substance precipitated by alcohol there was a sort of toxin-ferment which acted upon the nervous centers and disorganized the relations of the nerve cells. In his conclusions he says:

> In studying the products contained in different species of worms, we have isolated two toxic substances, one of which acts upon the nervous centers, while the other acts upon the muscles. We are therefore justified in suspecting the importance of these factors in verminous maladies. The critical study of this subject has brought to our attention a large number of symptoms analogous to those provoked by the injection of the toxic substances. * * * Our chemical theory, deduced from our experiments, permits us to understand how good health is possible in spite of the presence of worms. This result should occur whenever the excretion eliminates a quantity [of the toxic materials] equal to the absorption, for in this case the dose contained in the organism is not sufficiently active. The troubles correspond to the accumulation of toxic products; one readily comprehends that when some morbid influence becomes effective, it may determine the appearance of symptoms due to worms, which had been present for a long time without manifesting themselves. (Translation.)

In the case of *H. nana* it seems probable that the elimination of toxic materials which are absorbed by the host is one of the most important factors in the etiology of symptoms. Upon this point Linstow (1896b, pp. 190–191), after reviewing shortly the symptoms which have been attributed to the parasite, remarks:

> That such a minutely small, delicate animal can not produce these serious disturbances through mechanical irritation, perhaps does not need the proof that its virulence must be very intense. (Translation.)

The analysis of the symptoms reported in the various cases of *Hymenolepis nana* is complicated by a number of circumstances. Among others, the question arises as to whether the phenomena exhibited were due to helminthiasis, or to other causes; this question is more or less definitely decided in some instances by the effect of anthelmintic treatment. Again, in those cases in which there was a multiple infection, to what extent did *Hymenolepis nana* influence the symptoms and how much are the other parasites to be blamed? This is a question which can not be answered with certainty, but if the other parasites are comparatively few in number, as manifested by the number of eggs in the feces or by the number of worms passed after treatment, and are of kinds which do not usually cause much trouble, or if the symptoms disappear and recur after successive treatments in correspondence with the recurrence in the feces of the eggs of *H. nana*, we may assume that it is by the latter parasite that the symptoms are chiefly determined.

The presence or absence of symptoms[a] has been noted in more or less detail in 49 out of the 101[b] cases.

Of the 49 cases, 3 (Nos. 54, 57, 89) showed no symptoms whatever which could be traced to *H. nana*. It is only very remotely possible that there was any connection between the presence of *H. nana* in cases 1 and 3 and the diseases mentioned in these two instances, viz. meningitis and anemia, fatal in both cases. In 9 other cases (Nos. 10, 11, 13, 14, 15, 35, 53, 86, 101) the symptoms were only slight. In case 35, although thousands of *H. nana* were present, there were no symptoms of any kind exhibited, with the exception of occasional slight abdominal pains. Although several hundred specimens, besides numerous *Oxyuris* were passed after successive treatments in case No. 53, the patient was healthy in every respect and showed no symptoms except an itching of the nose. In 4 cases (Nos. 6, 47, 82, 97) the severity of the symptoms is not defined (in Nos. 82 and 97, however, they were probably slight). The symptoms in the 31 cases remaining are more or less severe. Only 17 of them, however (Nos. 7, 8, 32, 33, 34, 36, 37, 38, 39, 41, 42, 43, 44, 49, 81, 94, 95), are marked by symptoms in which the influence of *Hymenolepis nana* can be definitely traced, either by the disappearance or improvement of the symptoms after the expulsion of *H. nana* in those cases in which there seemed to be no other parasites present, or, if present, few in number compared with *H. nana;* or by the correspondence between the reappearance of *Hymenolepis* eggs in the feces after treatment, and the recurrence of symptoms.

In 13 (Nos. 7, 8, 32, 33, 34, 37, 38, 39, 42, 43, 49, 94, 95) of these 17 cases, some disorder of the digestive system was noted. The relative frequency of symptoms referable to the digestive system is as follows:

Bulimia or increased appetite, 3 cases (Nos. 7, 8, 39).

Perversion of appetite, 1 case (No. 95).

Gastric dyspepsia and difficult digestion, 1 case (No. 38).

Functional gastro-intestinal disorders, 1 case (No. 37).

Frequent vomiting, 1 case (No. 49).

Abdominal pain or paresthesia, 11 cases (Nos. 7, 8, 33, 34, 37, 38, 39, 42, 43, 49, 94). In one of these cases (No. 38) there was a sensation of crawling in the abdomen, and heat in the epigastrium; in another (No. 43) pain, and crawling and gnawing sensations; in another case (No. 42) pain and a sense of pressure; it was noted in one case

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[a] This is leaving out of consideration the symptoms in cases Nos. 51 and 52, not available to me on account of the Russian text in which they were recorded, and also the symptoms which may have been mentioned by Venuti (1895) in connection with his 23 cases, but his paper, unfortunately, is not at present accessible.

[b] The list of symptoms was compiled before the discovery of cases 102 to 106, which are therefore not included in the discussion. The ward records of these five cases showed, however, no symptoms which could be traced to the presence of the parasites.

(No. 39) that the pain in the epigastrium increased on palpation: in 2 cases (Nos. 33, 34) the pains were frequent.

Diarrhea. 3 cases (Nos. 49, 94, 95). In one case (No. 49) the diarrhea was lienteric in nature and of long standing, and in a second case (No. 95) it had persisted continually for two years.

Diarrhea alternating with constipation, 2 cases (Nos. 33, 34).

Severe intestinal troubles, 1 case (No. 32).

Nervous symptoms were noted in 15 cases (Nos. 7, 8, 33, 34, 36, 38, 39, 41, 42, 43, 44, 49, 81, 94, 95). In 11 of these cases convulsions or spasms occurred.

Epileptiform convulsions, 7 cases (Nos. 7, 8, 33, 34, 36, 38, 39). Of these, 3 were reported cured after treatment, while in the others the symptoms disappeared for some time after treatment but later recurred, and in 2 (Nos. 33, 34) of these latter there was no corresponding reappearance of eggs in the feces when the symptoms recurred after having ceased for several months.

Choreic convulsions, 1 case (No. 42).

Clonic spasms of extremities, 2 cases (Nos. 41, 43).

Nodding spasm of head, 1 case (No. 49). This symptom was improved but not cured after the expulsion of *H. nana.*

Diffuse tremor of frequent occurrence, 1 case (No. 38).

Paralysis or paresis was seen a number of times.

Weakness of right side of body, 2 cases (Nos. 41, 43).

Distortion of mouth, 2 cases (Nos. 41, 43).

Strabismus and diplopia, 6 cases (Nos. 39, 40, 41, 42, 43, 49). In 1 of these cases (No. 41) the strabismus was not cured and showed only very slight signs of improvement after anthelmintic treatment.

Difficult speech, 3 cases (Nos. 41, 42, 43).

A number of other so-called reflex symptoms were encountered.

Vertigo, 1 case (No. 44).

Headache, 5 cases (Nos. 39, 41, 43, 44, 49).

Nasal pruritus, 1 case (No. 49).

Numbness in lumbar region, 1 case (No. 44).

Diminished vision, 1 case (No. 42).

Mental symptoms, 5 cases. Two cases (Nos. 38, 43) were melancholy, taciturn, stupid; in 2 others (Nos. 7, 8) there were melancholia, indolence, and weakening of the mental faculties; 1 case (No. 49) was drowsy.

Respiratory disorders, 4 cases. Dyspnea occurred in 2 cases (Nos. 37, 48), in one of which it had been continual during two years, and was cured immediately after the expulsion of *H. nana;* in 1 case (No. 38), a scrofulous subject, there was a rough, diffuse, vesicular murmur of the lungs, whether cured after anthelmintic treatment is not stated; and in 1 case (No. 41) there was an occasional dry spasmodic cough.

Nocturnal enuresis, 1 case (No. 81).

Cardiac palpitation, 1 case (No. 39).

Shivering, grinding of teeth, biting of lips, 1 case (No. 49).

Pupils unequal, but reacting to light, 1 case (No. 42).

Fever, 3 cases. In 1 case (No. 49) there was said to be some fever; in 2 cases (No. 94, 95) the fever was irregular and intermittent, in 1 of which it appeared at intervals for two years.

Restless sleep, 1 case (No. 94).

Somnambulism, 1 case (No. 38).

Occasional remark is made as to the general appearance; usually the nutrition does not seem to be much affected.

Emaciation, 1 case (No. 49).

Paleness, 4 cases (No. 39, 42, 43, 49).

Weak, delicate, scrofulous, 1 case (No. 38).

With regard to the phenomena exhibited by the remaining cases in which symptoms were noticed, there is no way of demonstrating whether the presence of *Hymenolepis nana* was anything more than an attendant circumstance, indeed, in many of the cases it is quite apparent that there could have been no causal relation between the presence of the tapeworm and the symptoms, while in others, in which such a connection seems more or less probable, the evidence is too incomplete to warrant such an assumption, and in a number of these latter it is furthermore questionable whether the other parasites present might not be of equal or greater importance in the etiology of symptoms. Following is a list of symptoms, with their frequency, taken from all the reports of cases in which symptoms were noted, without regard to questions of etiology:

Disorders of the digestive system occurred in 28 cases.

Diarrhea, 9 cases.

Diarrhea, alternating with constipation, 2 cases.

Constipation, 1 case.

Diminished appetite, 3 cases.

Increased appetite, 4 cases.

Capricious appetite, 2 cases.

Perverted appetite, 2 cases.

Vomiting, 3 cases.

Abdominal pain or paresthesia, 16 cases.

Thirty-three cases were marked by symptoms connected with the nervous system; in 11 of these cases the nervous symptoms were only slight. A number of symptoms occurred as follows:

Epileptiform convulsions, 9 cases.

Choreic convulsions, 1 case.

Clonic spasms of extremities, 2 cases.

Nodding spasm, 1 case.

Frequent, diffuse tremor, 1 case.

Sinistral hemiparesia, 1 case.

Weakness of right side, 2 cases.

Ataxia and weakness of legs, 1 case.
Strabismus and diplopia, 6 cases.
Nystagmus, 1 case.
Disturbed vision, 1 case.
Diminished vision, 1 case.
Headache, 10 cases.
Disturbed sleep, 3 cases.
Fever, 7 cases.
Vertigo, 2 cases.
Difficult speech, 3 cases.
Mental symptoms, 7 cases.
Nasal pruritus, 3 cases.
Formication of body, 2 cases.
Numbness of lumbar region, 1 case.
Nocturnal enuresis, 1 case.
Cardiac palpitation, 2 cases.
Shivering, grinding of teeth, biting of lips, 1 case.

Of other phenomena not directly connected either with the digestive or nervous systems the following may be noted:

Chyluria, 1 case (No. 87). The doubtful connection of *Hymenolepis* with this case has already been remarked above in the discussion of the case.

Slight eosinophilia, 1 case (No. 82). So far as I have found, this case is the only one in which the results of a blood examination were reported.

Paleness, 13 cases.

Emaciation, 4 cases.

With regard to the symptoms which have been enumerated it will be noticed that there are no essential peculiarities to distinguish them from the symptoms found with the larger tapeworms (*Tænia*). In character the symptoms are similar in both instances, being remarkable chiefly on account of their variety and lack of uniformity.

According to the manner in which the cases are selected, a variety of results regarding the frequency of symptoms may be obtained from a comparison of *H. nana* with other tapeworms.

The cases of *H. nana* which showed severe nervous symptoms—taking into consideration all such cases without regard to the probability that in many of them the symptoms were due entirely to other causes than the presence of the parasite—form 45 per cent of the 49 cases in which the presence or absence of symptoms was distinctly referred to, and 21 per cent of the entire number.[a] Seeger's table (see p. 66) gives the percentage of severe nervous symptoms occurring in 100 cases of tapeworm as 68. Seeger, however, in making up his statistics, apparently has used only such cases as exhibited definite symptoms, and, moreover, has not given due consideration to possible causes of the symptoms other than the presence of *Tænia*. A comparison between the 49 cases of *H. nana* referred to and Seeger's cases is, nevertheless, not unwarranted. Not only in the latter as in the former is no attention paid to possible causes in the etiology of symptoms other than the presence of tapeworm, but they are in a sense selected cases. Seeger's cases were selected because of the occurrence of symptoms, and similarly, in connection with the cases of *H. nana* just mentioned, there has been a sort of selection, namely: If symptoms had not occurred in nearly all of these cases the circumstance of infection with *H. nana* would not have been discovered; these cases were thus picked out automatically from among probably a large number of cases, the remainder of which were without symptoms and thus never came under observation.

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[a] See footnotes, p. 71.

Severe nervous symptoms, apparently determined by the presence of tapeworm, were present in at least 10 per cent of Cobbold's cases (see p. 67). Convulsions were present in only 3 per cent of Hirsch's cases (see p. 66), but other phenomena occurred in a considerable number which will allow an estimate of severe nervous symptoms in about 10 per cent of the cases. Not more than 12 to 15 per cent of all[a] the cases of *H. nana*, or 30 per cent of the cases in which the presence or absence of symptoms has been definitely reported, exhibited severe nervous symptoms attributable with any degree of certainty to the action of the parasite.

A comparison with Seeger's statistics tends to show that severe symptoms are less common in cases of *H. nana* than in cases of other tapeworms, while comparison with the statistics of Cobbold and Hirsch indicates that grave nervous disturbances are more common in cases of *H. nana* than in cases of other tapeworms. All of these comparisons are open to criticism, but the first, although perhaps the most artificial of the three, probably arrives nearer the truth than either of the others, and it may be affirmed that severe effects from the presence of *Hymenolepis nana* are no more common than from the presence of other tapeworms, but on the contrary are very likely much less common. The high percentage of severe effects with cases of *H. nana* as compared with cases of other tapeworms is no doubt due, in part at least, to the fact that a proportionately greater number of cases of *H. nana* pass unnoticed than of larger tapeworms. The presence of a large tapeworm is usually made manifest, sooner or later, by the passage of segments, while a microscopic examination is necessary to determine the presence of *H. nana*, and, as already remarked, unless there happen to be symptoms which will bring the patient under medical observation, in which case a fecal examination may be made, the chances are very much against the diagnosis of any particular case among the general population. Thus it has happened that a comparatively large number of cases have presented themselves in which severe symptoms were associated with the occurrence of *Hymenolepis nana*, while probably a very large number of cases have never been noticed because there have been no symptoms. A case of *Tænia saginata* or *T. solium*, on the other hand, is very likely to come under observation; the average individual, when he has once observed the passage of worms from his intestine, usually does not delay, whether there are any other unpleasant symptoms or not, to seek relief from the presence of his unwelcome guests; the case consequently stands a very good chance of being placed somewhere on record. Another point might be noticed in this connection. *Hymenolepis nana* is more especially a parasite of children; the larger tapeworms are more common among adults. It is rather to be expected that children would, in general, experience more severe effects from parasitic infection than adults; for example, nearly half of Cobbold's cases (as noted above), which exhibited severe nervous symptoms, were children, while the great majority of all his cases were adults; an indiscriminate comparison of statistics, therefore, without taking into account the question of age of affected individuals, is not likely to give a true idea of the relative nocuity of the different parasites.

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[a] See footnotes, p. 71.

The symptomatology of helminthiasis with *Hymenolepis nana* may be summed up as follows:

The effects of helminthiasis with *H. nana* are no more severe than may occur from infection with other tapeworms, nor, if it is considered that many cases of the former are probably overlooked, are serious symptoms more common. Although the effects are usually so slight, even when the parasite is present in considerable numbers, that the symptoms are only very mild or absent entirely, it occasionally happens, as with the larger tapeworms, that severe symptoms (persistent diarrhea, epileptiform attacks, etc.) are exhibited. The most frequent symptoms determined by the presence of *H. nana* are abdominal pain, which may or may not be associated with diarrhea; convulsions of various sorts, frequently epileptiform; headache and strabismus. Nasal or anal pruritus, common in cases of infection with other tapeworms, is rarely seen with *H. nana*. In many cases in which a neuropathic condition is already present, infection with *Hymenolepis nana* is likely to result in an aggravation of the morbose phenomena and, in general, a predisposition to nervous disease seems to be the important factor in the appearance of nervous symptoms.

DIAGNOSIS.

In speaking of the diagnosis of helminthiasis, Blanchard (1891a, p. 100) remarks as follows:

> The persistence of digestive troubles and the diversity and irregularity of other symptoms are very suggestive of helminthiasis. The diagnosis is rendered more

> probable when the patients are children. Intestinal parasites, in fact, play a considerable part in the production of infantile maladies, a circumstance which is systematically disregarded by a great many physicians. When helminthiasis is once suspected, one ought to determine as nearly as possible to what species the offending parasite belongs. Success in treatment depends upon this point; a remedy which is sure in its effects upon one species may be useless against other worms. Entire worms or fragments which have spontaneously quitted the intestine may be found in the dejecta. A careful examination of these furnishes valuable data with regard to the treatment to be pursued, but one ought not to limit one's self to such a superficial means of determination. Since it frequently happens that several parasites live side by side in the intestine of the same individual, it is indispensable, especially in grave cases, to make a more careful examination of the feces, in order to determine exactly what different species may be harbored by the patient. This examination presents no difficulties, and only requires a little patience, since all the eggs are not equally easy to distinguish. The egg of each species of parasite, however, has a very characteristic shape and size, which renders the diagnosis very easy. (Translation.)

To make the examination it is necessary simply to rub up with a drop of distilled water on a glass slide, a very small particle of the feces to be examined, cover with a cover glass, and examine with a moderately high power, a Zeiss 4 or 8 mm., Leitz 5 or 7, Bausch and Lomb one-half or one-fourth, or other equivalent objective. Some care is requisite in looking for the eggs of *H. nana*, otherwise they are very liable to be passed unperceived, because of their great transparency. The presence of three pairs of hooks on the embryo contained within an egg indicates that it is a cestode egg, while the presence also of two distinct membranes, an inner one closely investing the embryo, and an outer separated from the inner by a considerable intervening distance, is characteristic of *Hymenolepis* eggs. The shell of the egg of *Tænia saginata* or of *T. solium* is thick, radially striated, and lies closely against the embryo. The outer membrane of the egg of *Hymenolepis diminuta* may likewise be radially striated, a character, which when present will distinguish it from *Hymenolepis nana*. The substance intermediate between the outer and inner membranes is more prominent in *H. diminuta*, and there are no filaments attached to the poles of the inner membrane as in *H. nana*. The presence of polar papillæ on the inner membrane is a characteristic feature of *Hymenolepis* eggs not always readily apparent. The filaments in the egg of *H. nana* are often difficult to distinguish, but in case they are not seen at once, careful observation of a number of specimens, especially if an immersion lens be used, will usually reveal them.

Charcot-Robin crystals, which were found by Leichtenstern (1892) almost constantly present in the feces of patients with helminthiasis, have not been found in cases of *Hymenolepis nana*.

It is doubtful whether the spherical bodies described by Senna and referred to above (p. 33) can be considered of diagnostic importance. As already remarked, Senna at first considered these bodies to be eggs in course of development, but since he found them not only in feces which contained eggs of *H. nana*, but also in feces in which the presence of eggs could not be established, he was inclined to discard his former interpretation. It is possible, in those cases in which the spherical bodies but no eggs were present, that there were in reality worms in the intestine, which, however, had not attained their full growth; consequently the eggs had only partially developed and were found in the feces only in their immature stages.

TREATMENT.

Male fern is the only remedy which has met with any degree of success in the treatment of *Hymenolepis nana*. Kousso, kamala, santonin, thymol, or pomegranate proved ineffective in the cases in which any of these were tried (Nos. 4, 5, 7, 8, 38, 43, 48, 53, 89).

The usual precautions should be taken in the treatment with male fern, namely, taking care to have the patient in the best possible physical condition, and preceding the administration of the tæniacide by a preparatory treatment of mild laxatives and a light diet in which the amount of starchy foods is reduced to a minimum (Eichhorst, 1901a, p. 298). In the technic of tapeworm treatment some authors recommend a salad of dried herring, garlic, and onions, the evening before the administration of the male fern; this procedure was followed in a number of cases of *Hymenolepis nana*, but to what advantage does not appear. The preparation of male fern to be employed is the official oleo-resin (Oleo-resina aspidii, U. S. P.), or ethereal extract of European pharmacy, which must be fresh to be effective. The dose for adults is 2 to 4 cc. (fl. ʒ ss.-j). There is some danger attending its use; a number of cases are on record in which poisoning occurred, several resulting fatally. Six drams and even less have caused death. The symptoms of poisoning were vomiting, vertigo, headache, diarrhea, severe pains in the abdomen, dyspnea, cold sweat, coma, convulsions, mania, and temporary or permanent blindness.

After the preliminary treatment the male fern is given in the morning upon an empty stomach. In its administration various methods have been used; it has been given in pills, mucilage, syrup, electuary with calomel, etc. Eichhorst (1901a, p. 299) has obtained satisfactory results with gelatin capsules. A number of small doses at intervals, or one, two, or three larger doses, may be given; Mertens (1892) found the latter procedure preferable.

One treatment may not suffice for a cure; in at least 20 of the cases of *H. nana* the eggs were found in the feces after treatment, usually after an interval of about fifteen days, and in several instances 4 or 5 repetitions of the treatment were necessary.

PROPHYLAXIS.

Upon the assumption that *H. nana* of man is the same form as *H. murina* of the rat, and that development occurs in man in the manner demonstrated by Grassi for the rat, namely, without a change of hosts, the prophylactic precautions to be observed are evident.

As far as possible banish rats and mice from the premises, and keep food out of their reach, especially food that is eaten raw, or after cooking is kept for some time before being eaten.

Considering also the possibility that some insect may act as an intermediate host, insects should, on this account, as well as for esthetic and general hygienic reasons, be kept out of the food.

Of course not only food, but other objects which have been contaminated by the feces of rats or mice, or of an infected person, may convey infection by carrying the eggs to the mouth; hence, articles (including fingers) which are placed in the mouth should be clean, and unnecessary objects should be kept out of the mouth; this rule, which is applicable also in a scheme of prophylaxis against parasitic infection in general, should be enforced, especially in the case of children, who are notoriously indiscreet with regard to what they put in their mouths, and in view of the possibility mentioned in the foregoing paragraph, special care might well be taken that they do not, accidentally or willfully, put in the mouth and swallow insects. The feces of infected persons should be properly disposed of.

Blanchard (1891a, p. 105) epitomizes the subject of prophylaxis in the following words:

> From whatever point of view examined, the great problem of the suppression of parasitic diseases, whether they be infectious or not, is summed up in this formula: Cleanliness, always cleanliness.[a]

The Flavopunctate Tapeworm—HYMENOLEPIS DIMINUTA (Rudolphi, 1819) Blanchard, 1891.

HISTORICAL REVIEW.

The original description[b] of the species *Hymenolepis diminuta* was given by Rudolphi (1819, pp. 689–690) as follows:

[a] A quelque point de vue qu'on l'examine, le grand problème de la suppression des maladies parasitaires, qu'elles soient ou non infectieuses, se résume donc en cette formule: de la propreté, encore de la propreté.

[b] *Tænia diminuta* R. n. sp.—T. capite obconico, collo longo, tenui; articulis anticis bevissimis [sic], reliquis subcuneatis obtusis. *Hab.* In intestinis *Muris ratti* gravidi Olfers in Brasilia reperit.

Specimina sex ad novem pollices et quod excurrit longa, nam fragmentis computatis forsan longiora. *Caput* obconicum, *osculis* anticis majusculis, exacte T. omphalodis, quam Mantiss, p. 491, descripsi, sed multo minus, unde nomen triviale desumsi. *Collum* longum tenue. *Articuli* priores rugaeformes, sensim majores, semper tamen longitudinis ratione habita breves, angulis obtusis: posteriores passim irregulares, sed breves. *Ova* subglobosa, mediocria.

Obs. Omphalodem dixerim, nisi caput multo minus, ova major forent; haec forsan in Omphalode crescere posse contenderes, sed caput non augebitur.

Tænia diminuta R. n. sp.—*Tænia:* Head obconical; neck long, slender; anterior segments very short; the rest, subcuneate, obtuse.

Habitat.—Collected by Olfers in Brazil from the intestines of a gravid rat (*Mus rattus*). Specimens 6 to 9 inches or more in length, and, since the measurements were taken from fragments, perhaps longer. Head obconical, with rather large suckers situated anteriorly; it is similar to that of *T. omphalodes* (described, Mantissa [Rudolphi, 1819], p. 491), but much smaller, for which reason I have chosen the specific name [*diminuta*]. Neck long and slender. Segments at first resembling corrugations, gradually becoming larger, with their length always remaining less than their width, with obtuse angles; posterior segments more or less variable, but short. Eggs subglobose, of medium size.

Note.—I would have said it were *omphalodes* if the head were not much smaller and the eggs larger; the contention might be made that the eggs of *omphalodes* could grow larger; a head, however, will not increase in size. (Translation).

Some years later Creplin (1825a, pp. 71–72) described as a new species a tapeworm from the rat which he named *Tænia leptocephala.* The following is translated from his description:[a]

Taenia: Head slender; suckers large, globose; rostellum, conical, truncated, unarmed; neck, continuous, elongated; segments all short.

Habitat.—I once collected, April 19, 1822, two specimens of this tapeworm in the intestines of a mouse (*Mus musculus*). Of these I took out only one with a head, and a fragment of the posterior part of the body.

I am compelled to give a description from these specimens as already preserved for some time in alcohol, since I did not have time to examine them when they were fresh.

The length of the worm with the head equals 10 to 11 inches; of the other without a head about 9. The width, decreasing from the tail toward the head, measures a little more than a line at its maximum in the posterior part of the body. Color white.

Head small, slender, furnished with large globose suckers, which when projecting have orbicular apertures, likewise large, and with a rostellum, conical, truncated, and unarmed. With the suckers withdrawn the length of the head equals its thickness at the base. Neck rather long, slender, continuous with the head, flattened. Anterior segments resembling corrugations; following segments very short,

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[a] T. capite tenui, osculis maximis globosis, rostello conico truncato inermi, collo continuo elongato, articulis omnibus brevibus.

Hab. Semel (d. 19. Apr. 1822) in int. *Muris musculi* offendi hujus Tæniæ duo specimina, quorum alterum solum cum capite extraxi, et fragmentum corporis postici.

Descriptionem dare coactus sum de speciminibus illis jam per quoddam tempus in spiritu vini servatis, cum recentium examinandorum tempus deficeret.

Longitudo vermis capite adhuc gaudentis æquat decem ad undecim pollices, alterius capite privi novem circiter. *Latitudo*, a cauda ad caput semper decrescens, maxima, postica in parte lineam parum excedit. *Color* albus.

Caput parvum, tenue, *osculis* vero magnis, globosis, apertura orbiculari pariter magna, exstantibus, et *rostello* caput ipsum longitudine et basi sua etiam crassitie (osculis deductis) æquante, conico, truncato, inermi instructum. *Collum* satis longum, subtile, cum capite continuum, planum. *Articuli* antici rugæformes, sequentes brevissimi, marginibus lateralibus obtusis, reliqui omnes, semper breves, anticam partem paululum contractam, margines laterales interdum convexiusculos, interdum fere rectos, marginem posteriorem vero tumidulum exhibent. Ultimi articuli non adsunt. Foramina articulorum non vidi.

with obtuse lateral margins; all the rest, always short, present an anterior portion somewhat contracted, lateral margins sometimes slightly convex, sometimes almost straight, and a swollen posterior margin. Final segments not present. Openings of the segments not seen. (Translation.)

Dujardin (1845a, p. 579, pl. 12, fig. G) enlarged upon Creplin's account of the species *Tænia leptocephala*, adding sufficient detail to furnish a fairly complete description, and moreover recognized the apparent identity of Creplin's species and *Tænia diminuta* of Rudolphi. As translated his account reads as follows:

Tænia leptocephala.[a]—From 100 to 500 mm. long, from 1.5 mm. to 4 mm. broad, composed of very numerous and very short segments four to nine times as broad as long; head almost globular, from 0.26 mm. to 0.30 mm. broad, may lengthen itself by means of a conical, unarmed rostellum, sometimes very slender; suckers deep with very salient edge, 0.16 mm. broad; first segments very short, the following ones (male) six to nine times as long as broad; genital orifices unilateral; penis smooth, filiform; eggs almost globular with three envelopes; the outermost smooth at first, then finally granular, from 0.062 mm. to 0.074 mm. long; the middle one membranous; the innermost somewhat quadrangular, rounded, from 0.041 mm. to 0.042 mm. long; embryo from 0.032 mm. to 0.036 mm. with hooks from 0.015 mm. to 0.017 mm.

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[a] Ténia leptocéphale (*Tænia leptocephala*).—Long de 100 à 500 mm., large de 1 mm. 5 à 4 mm., formé d'articles très nombreux et très courts, quatre à neuf fois aussi larges que longs; tête presque globuleuse, large de 0 mm. 26 à 0 mm. 30, pouvant se prolonger en une trompe conique, inerme, quelquefois très mince; ventouses profondes à bord très saillant, larges de 0 mm. 16; premiers articles très courts, les suivants (mâles) six à neuf fois aussi longs que larges; orifices génitaux unilatéraux; pénis lisses, filiformes; œufs presque globuleux à trois enveloppes; l'externe lisse d'abord, puis finement granuleuse, longue de 0 mm. 062 de 0 mm. 074; la moyenne membraneuse; l'interne un peu quadrangulaire, arrondie, longue de 0 mm. 041 à 0 mm. 042; embryon de 0 mm. 032 à 0 mm. 036 avec des crochets de 0 mm. 015 à 0 mm. 017.

Sous ce nom, donné par M. Creplin à un ténia incomplétement décrit, je réunis plusieurs ténias dont il faudra peut-être faire deux ou trois espèces; savoir: 1° un ténia long de 520 mm., large de 4 mm. en arrière, avec la tête de 0 mm. 285, trouvé dans un rat (*Mus rattus*) à Rennes, ses pénis ou lemnisques sont larges de 0 mm. 019, saillants de 0 mm. 06, ses testicules sont flexueux et non pelotonnés et ne s'avancent pas au-delà du milieu de chaque article; ses œufs ont l'enveloppe externe elliptique longue de 0 mm. 066 à 0 mm. 074; 2° plusieurs ténias trouvés à Rennes dans des surmulots (*Mus decumanus*) ayant la tête large de 0 mm. 24 à 0 mm. 26, les pénis peu saillants, larges de 0 mm. 016, et les testicules repliés et pelotonnés dans presque toute la largeur des articles mâles; les œufs presque globuleux sont longs de 0 mm. 068; 3° fragments de ténia longs de 100 à 200 mm. provenant d'un autre surmulot, et remarquables par leurs pénis très longs, filiformes, larges de 0 mm. 028; les derniers articles larges de 2 mm. 2 sont longs de 0 mm. 75 et contiennent des œufs ronds larges de 0 mm. 068; 4° des ténias longs de plus de 150 mm., sans tête, trouvés dans deux mulots (*Mus sylvaticus*) à Rennes; ils sont larges de 0 mm. 7 en avant et de 4 mm. 5 à 5 mm. en arrière, où les derniers articles remplis d'œufs sont dix à quinze fois aussi larges que longs; les articles intermédiaires mâles ont le réceptacle du pénis en forme de massue, ils laissent sortir des spermatozoïdes filiformes très-longs, mais je n'ai pas vu de pénis saillant; les œufs sont globuleux, larges de 0 mm. 062 à 0 mm. 07, mais plus ordinairement de 0 mm. 065; leur coque est granuleuse (voyez Atlas, pl. 12).—Il faut, je crois, rapporter à la même espèce celle que Rudolphi nomme *Tænia diminuta*.

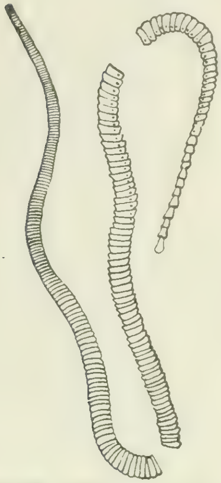

FIG. 68.—Strobila of *H. diminuta*. Natural size. (After Weinland, 1861, pl. 4, fig. 10, from Leuckart, 1863, p. 398, fig. 116.)

> Under this name, given by M. Creplin to an incompletely described tapeworm, I include several tapeworms which will perhaps have to be subdivided into two or three species, namely: First, a tapeworm 520 mm. long, 4 mm. broad in the posterior portion, with a head 0.285 mm. [broad], found in a rat (*Mus rattus*) at Rennes; its penes, or lemnisci, are 0.019 mm. broad, projecting 0.06 mm.; its testicles [probably misinterpretation of seminal vesicle and receptacle] are flexuous and not conglobate, and do not project beyond the middle of each segment; the external envelope of its eggs is elliptical, from 0.066 mm. to 0.074 mm. long; second, several tapeworms found at Rennes in brown rats (*Mus decumanus*) with a head from 0.24 mm. to 0.26 mm. broad, the penis not very salient, 0.016 mm. broad, and the testicles [probably misinterpretation of seminal vesicle and receptacle] folded and conglobate, throughout almost the whole breadth of the male segments; the eggs, almost globular, are 0.068 mm. long; third, fragments of tapeworm from 100 to 200 mm. long, coming from another brown rat, and remarkable because of their very long filiform penis, 0.028 mm. broad; the last segments, 2.2 mm. broad, are 0.75 mm. long, and contain round eggs 0.068 mm. broad; fourth, tapeworms more than 150 mm. long, without a head, found in two field mice (*Mus sylvaticus*) at Rennes; they are 0.7 mm. broad in the anterior portion and from 4.5 mm. to 5 mm. in the posterior portion, where the last segments, filled with eggs, are ten to fifteen times as broad as long, the receptacle of the penis in these intermediate male segments is club-shaped; these segments send out very long filiform spermatozoa, but I did not see a salient penis; the eggs are globular, from 0.062 mm. to 0.07 mm. broad, but more commonly 0.065 mm. broad; their shell is granular (see Atlas, pl. 12). I think we should refer to the same species that which Rudolphi calls *Tænia diminuta*. (Translation.)

Weinland (1858) was the first to report the occurrence of *Hymenolepis diminuta* in man; he described it as a new species, *Hymenolepis flavopunctata*, in the following words (see also p. 98):

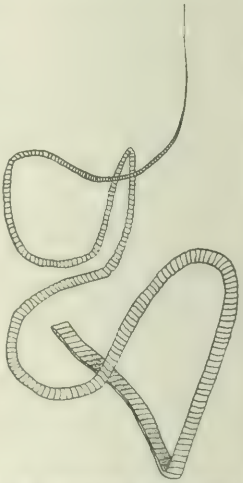

FIG. 69.—Strobila of *H. diminuta*. Natural size. (After E. Parona, 1884, fig. 1.)

> The length of the whole worm is between 200 and 300 mm., that is, from 8 to 12 inches. There were pieces of 50 mm. in length, consisting of very young joints, only one-fifth mm. long and 1 to 1¼ mm. broad; again, other pieces, about 100 mm. long, consisting in their anterior half of white, immature joints, one-third to one-half mm. long, and 1½ to 2 mm. broad, while the mature joints of the posterior half, which are of a grayish tint (produced by the eggs which they contain), average 1 mm. in length and 1½ to 2 in breadth. In the young joints the sides form straight lines, the transverse diameter being equal throughout the joint; in the riper ones they are round and bulged, and the transverse diameter is the greatest in the midst of each joint. One of the pieces, which is especially mentioned in the catalogue of Dr. J. B. S. Jackson, shows the form of the joints when fully matured and soon to be freed as proglottides. They are in this specimen

riangular in shape, being narrow in front and suddenly broadening behind, evidently having already discharged the eggs from the anterior part of the joint, while generally proglottides deposit their eggs only after they are free. In other specimens these last joints, being yet quite full of eggs, are more oblong, even with the transverse diameter longer than the longitudinal. In either case the proglottides are very loosely connected with each other. In relation to the genital organs, we have mentioned above the yellowish spot lying near the middle line in the anterior part of each joint, and it is for this we have called the species *flavopunctata*. These spots are the testicles [seminal receptacle, see p. 89], appearing under the microscope as a globular gland, with another smaller one attached to it; this latter one runs out, toward the side of the joint, into a long, slender canal, in which lies the penis. The genital openings are situated all on one and the same side of the worm, while in all true Tænias (see p. 51, note) known thus far, they are found irregularly, now on one, now on the other side. The configuration of the uterus, also, differs greatly from that in the genuine Tænias. There is no main stem in the midst with lateral branches, as in the latter; but, on the contrary, the eggs are crowded over the whole joint. It sometimes appears as if they were arranged in straight lines along the joint; but this is certainly owing only to the regular lines of muscular contractions. Only fresh specimens can decide ultimately the structure of the uterus. From a careful dissection of the younger joints, we should judge that it consists of globular blind sacs, located here and there in the joint, and connected by fine tubes terminating finally in the vagina. The most characteristic feature in this worm is its eggs, the number of which may be counted by thousands in each ripe joint. They are very large, measuring 0.054 mm. in diameter, and under a low power of the microscope appear as transparent balls with a yellow dot in them. With a higher power, we easily distinguish three distinct eggshells (figs. 9, 1, a, b, c). The outside shell is translucent, elastic, cracking in sharp angles under pressure, and only 0.0007 mm. thick; this shell is folded by application of glycerin. The second shell is membranaceous and irregularly wrinkled, thinner than the first, and immediately attached to it. This second shell, showing through the first, gives to the whole sur-

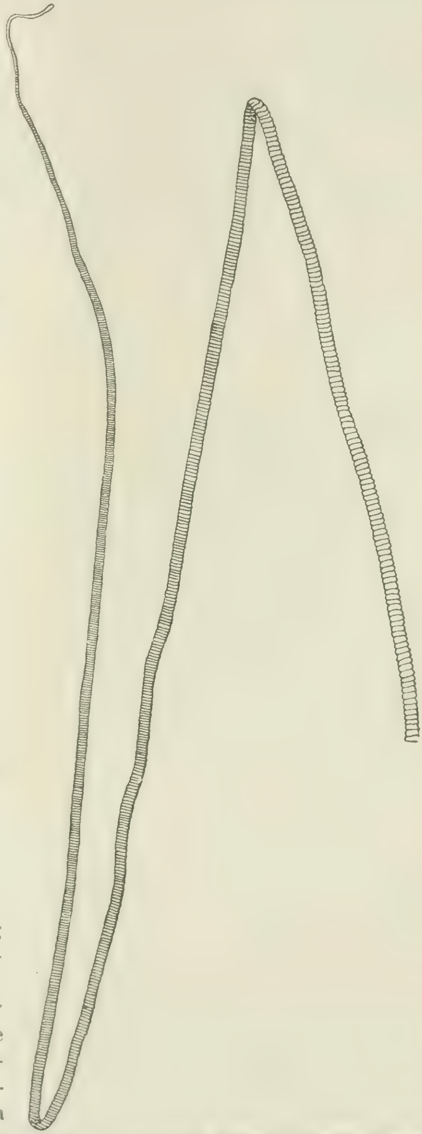

Fig. 70.—*Hymenolepis diminuta*. Natural size. (After Grassi, 1888 l, pl. 11, fig. 1.)

face of the egg a wrinkled appearance, though the first shell is in reality entirely smooth. The large cavity which is formed by these two outside shells contains a fluid (this fluid, which has the appearance of albumen, turns milk white when brought into contact with water. Such an albuminous fluid between the two egg-shells has also been noticed by Dujardin in the eggs of a Tænioid from *Fringilla domestica*, L.), in which swims the small globular embryo (measuring only 0.024 mm.), inclosed in a third shell, closely attached to it, but of considerable thickness (0.001 mm.). We can not state with certainty that there are three pairs of spines to this embryo; if there are any, they must be very small.

A number of points were added to Weinland's description, and several errors corrected by Leuckart (1863, pp. 397–400) from a study of material obtained from Weinland.

That *Hymenolepis flavopunctata* Weinland from man is in reality the same form as *Tænia leptocephala* Creplin and *Tænia diminuta* Rudolphi was definitely established by Grassi (1888).

The most complete anatomical description of *Hymenolepis diminuta* which has appeared is that given by Zschokke (1889, pp. 63–73, figs. 21–24).

Two species very similar to *H. diminuta* are known, *Hymenolepis relicta* (Zschokke) from the rat, and *H. megaloon* Linstow from a gopher (*Spermophilus* sp.). The former, although described by Zschokke as a distinct species, is so nearly like *H. diminuta* that it is a question whether the two ought not to be united in the one species, *H. diminuta*. Practically the only distinguishing characteristics seem to be differences in the length and the number of segments, upon the basis of which it would be a very difficult matter to draw a line separating the two forms. The second form, *H. megaloon*, which was described briefly by Linstow (1901), resembles *H. diminuta* except in one or two minor details, and is a very nearly related species.

ANATOMICAL DESCRIPTION.

The following account of the anatomy of *Hymenolepis diminuta* is based upon previous descriptions supplemented by original observations upon specimens both from man and from rats:

EXTERNAL ANATOMY.

Strobila.—The length varies from 10 to 60 cm. and the breadth posteriorly is from 2.5 to 4 mm. or as much as (?) 7 mm. (Packard, 1900).

Head. The size and form of the head (figs. 71–74) are variable, 200 to 600 μ in width, almost globular, but rather flattened; with 4 suckers, placed somewhat anteriorly, 80 to 160 μ in diameter, and a rudimentary, unarmed rostellum.

Rostellum.—The rostellum is in all essentials exactly similar to the rostellum of *Hymenolepis carioca* (see Ransom, 1902). When in a state of retraction the rostellum (figs. 72–74) has the appearance of a small elongated muscular sac embedded in the substance of the anterior part of the head, with a very slender, tube-like cavity extending into its anterior end from the outside. This cavity is lined with cuticula continuous with the cuticula covering the head, and is thus evidently produced by a simple invagination. The rostellum is sometimes seen slightly protracted, forming thus a conical tip on the anterior surface of the head. When retracted, the rostellum measured in two specimens 100 by 40 μ and 100 by 80 μ in length and width, respectively. Linstow (1878b), as Grassi (1888l) has remarked, erroneously described the rostellum of *H. diminuta* as a fifth sucker.

Neck.—The neck (fig. 72) is short, 0.5 mm. (Grassi, 1888l), and is generally somewhat smaller in diameter than the head.

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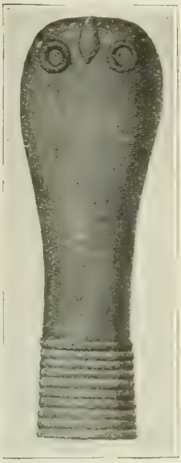

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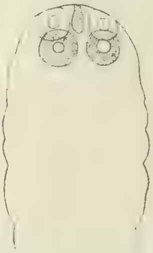

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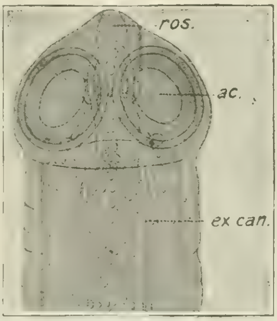

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Fig. 71.—Head and neck of *H. diminuta* from man. Enlarged. (After E. Parona, 1884, fig. 4.)

Fig. 72.—Head and anterior portion of *H. diminuta* from rat. Enlarged. (After Zschokke, 1889, pl. 1, fig. 21.)

Fig. 73.—Head of *H. diminuta*. Enlarged. (After Grassi, 1888l, pl. 11, fig. 5.

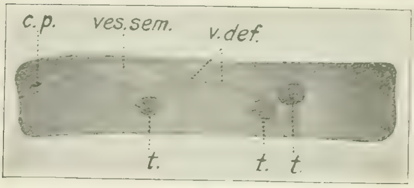
Fig. 74.—Head of *H. diminuta*: *ac.*, sucker; *ex. can.*, excretory canals; *ros.*, rostellum. Enlarged. (After Grassi, 1888l, pl. 11, fig. 2.

Segments.—The segments number 800 to 1,000 (Zschokke, 1889), 1,300 (Magalhães, 1896). As in nearly all tapeworms of numerous segments this character will be found to vary greatly. The young segments are 20 times as wide as long. The width of mature segments is 15 to 20 times the length, 6 to 10 times, or even not so much as twice, the length. The posterior borders of the segments are only slightly longer than the anterior borders of the following segments, and the appearance of serration is thus only slightly marked.

Genital pores.—The genital pores (figs. 75–77, 79, 80, 82, 83, 85, 87) are unilateral, situated on the left side in the anterior part of each segment at about the junction of the anterior and middle thirds. Occasionally the genital pore opens on the opposite side of the segment, but comparatively only a very few segments have the genital openings on the right side instead of the left.

Calcareous corpuscles are present, more commonly noticed in the anterior part of the strobila, are of variable size and form, but generally oval, measuring 8 to 13 μ by 4 to 6 μ (fig. 74).

NERVOUS SYSTEM.—Two prominent *longitudinal nerve trunks* extend throughout the strobila, one on each side, situated a short distance laterad from the excretory vessels. Two small *accessory longitudinal nerves* are also present on each side, lying close to the dorsal and ventral sides, respectively, of the main lateral longitudinal nerve. In each segment also, according to Zschokke (1889), the lateral trunks give off in the anterior and posterior regions of the proglottis, respectively, two nerves which run mediad, one in the cortical portion of the parenchyma, i. e., outside the layer of transverse muscle fibers,



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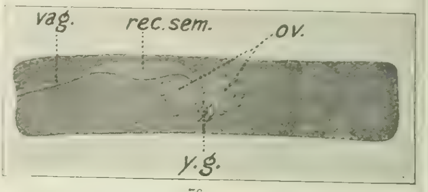

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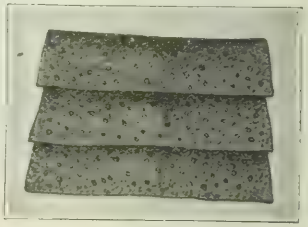
FIG. 75.—Proglottid of *H. diminuta* showing male organs: *c. p.*, cirrus pouch; *t.*, testis; *v. def.*, vas deferens; *ves. sem.*, vesicula seminalis. Enlarged. (After Grassi, 1888, pl. 11, fig. 10.)

FIG. 76.—Proglottid of *H. diminuta* showing female organs: *ov.*, ovary; *rec. sem.*, receptaculum seminis; *vag.*, vagina; *y. g.*, yolk gland. Enlarged. (After Grassi, 1888, pl. 11, fig. 10.)



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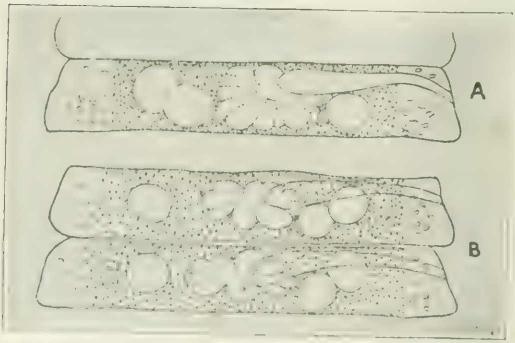

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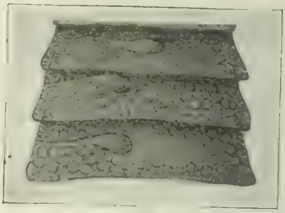

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FIG. 77.—Proglottids of *H. diminuta* showing usual, A, and unusual, B, position of testes. Enlarged. (After Grassi, 1888, pl. 11, fig. 14.)

FIG. 78.—Portion of strobila of *H. diminuta* about 1 cm. from the head. Enlarged. (After E. Parona, 1884, fig. 5.)

FIG. 79.—Portion from the middle of strobila of *H. diminuta*. Enlarged. (After E. Parona, 1884, fig. [illegible])

and the other in the central portion, namely, beneath the transverse muscles. These undoubtedly represent commissures which are known to occur in other forms, connecting the lateral longitudinal nerves. In the regions where these commissural nerves are given off the lateral nerves present *ganglionic enlargements* (Zschokke, 1889). The nerve trunks turn inward in the scolex, become thicker and are united at the base of the rostellum by a commissure richly supplied with nerve cells. Four nerves extend forward along the sides of the rostellum, within which, also, nervous elements are distinguishable. Although neither an anterior nerve ring surrounding the anterior part of the rostellum, nor nerves to the suckers have been definitely seen, Zschokke (1889) considers their existence probable, upon the basis of analogy with other forms.

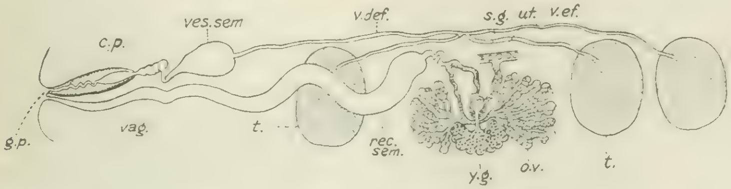


Fig. 80.—Male and female organs of *H. diminuta.* Transverse section: *c. p.*, cirrus pouch; *g. p.*, genital pore; *ov.*, ovary; *rec. sem.*, receptaculum seminis; *s. g.*, shell gland; *t.*, testis; *ut.*, uterus; *vag.*, vagina; *v. def.*, vas deferens; *v. ef.*, vas efferens; *ves. sem.*, vesicula seminalis; *y. g.*, yolk gland. Enlarged. After Zschokke, 1889, pl. 2, fig. 22.

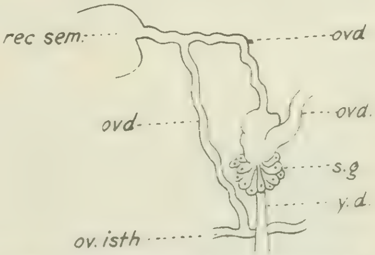


Fig. 81.—Point of union of female canals of *H. diminuta*; *ovd.*, oviduct; *ov. isth.*, isthmus connecting the right and left lobes of the ovary; *rec. sem.*, receptaculum seminis; *s. g.*, shell gland; *y. d.*, yolk duct. Enlarged. After Zschokke, 1889, pl. 2, fig. 23.

Muscular system.—Besides the subcuticular *circular* and *longitudinal muscle* fibres, there are present throughout the strobila, longitudinal, transverse, and dorso-ventral muscle fibers. The *longitudinal fibers* are arranged in bundles of 8 to 15 fibers which are placed in two series, an outer series or layer just beneath the layer of flask-like subcuticular cells which lie beneath the cuticula, and a second series, more or less distinct from the first, and more internally situated. The bundles are connected by numerous oblique fibers. The number of bundles is variable, but the bundles of the outer layer are more numerous than those of the second. Following the longitudinal fibers forward into the neck and scolex, the fibers of the outer series are seen, by the study of sections, to be derived from subcuticular longitudinal fibers of that region, while the fibers of the inner series continue on into the scolex and attach to the suckers and rostellum, relations already established by Lühe (1894,

1896) for other species, and referred to above in connection with *Hymenolepis nana*.

Transverse fibers are comparatively few, and are prominent at all, only in the region where one segment joins the next. The *dorso-ventral fibers* are also more prominently developed near the junction of the segments.

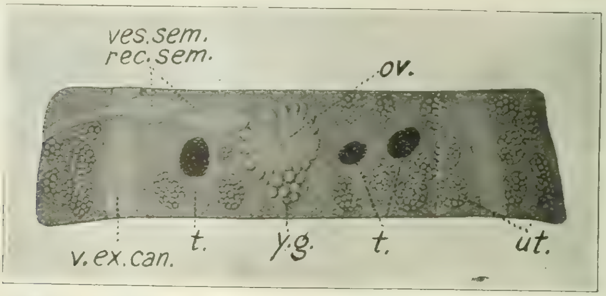


Fig. 82.—Proglottid of *H. diminuta* by transmitted light. Uterus developed and containing ova: *ov.*, ovary; *t.*, testes; *ut.*, uterus; *ves. sem.*, *rec. sem.*, vesicula seminalis and receptaculum seminis; *v. ex. can.*, ventral lateral excretory canal; *y. g.*, yolk gland. Enlarged. (After Grassi, 1888, pl. 11, fig. 12.)

The rostellum is supplied with longitudinal and circular fibers, an outer longitudinal and inner circular (Zschokke, 1889). In the scolex there are found muscle fibers running in various directions, with various attachments.

Excretory system.—The excretory canals (figs. 74, 82, 84, 88) are laterally situated. The ventral pair as usual are much the larger, and are connected in the posterior part of each segment by a transverse canal (fig. 84) of smaller caliber. The dorsal canals lie close to the dorsal side of the ventral canals, and are much smaller except in the scolex and the anterior part of the strobila where the ventral canals are of small diameter, only a little larger than the dorsal canals (fig. 74). In the scolex there is an anastomosis of the four canals behind the rostellum. Extending forward from this anastomosis, there are two loops, one on either side of the rostellum, into which also, the excretory system is extended by means of four very slender canals, which unite in the rostellum to form two closed loops, the dorsal canal of each side uniting with the corresponding ventral canal. Similar loops, as found by Mingazzini (1899), in *Hymenolepis nana* have already been mentioned in connection with that form.

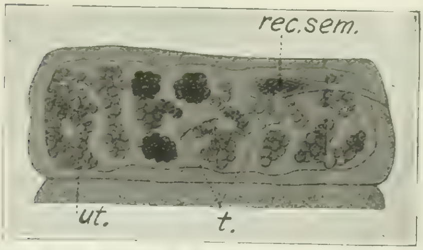


Fig. 83.—Proglottid of *H. diminuta* further developed than fig. 79: *rec. sem.*, receptaculum seminis; *t.*, remnants of testes; *ut.*, uterus. Enlarged. (After Grassi, 1888, pl. 11, fig. 12.)

REPRODUCTIVE SYSTEM.—The male reproductive organs develop more rapidly than the female and reach maturity sooner.

The cirrus pouch and vagina cross the excretory canals and the longitudinal nerve on the dorsal side.

Male organs.—Three *testes* (*t.*, figs. 75, 80, 82, 83) are normally present, two to the right and one to the left of the mass of female glands which occupy the median portion of the proglottis. Two testes, however, may often be found occupying the side toward the genital pore and only one on the other side (fig. 77B). Exceptionally, also, only two may be present, or there may be four to six. In shape the testes are oval or spherical and when fully developed occupy nearly the entire thickness of the central parenchyma.

Vasa efferentia (*v. ef.*, fig. 80) lead from the dorsal sides of the testes, and the three canals converging to meet near the median line in the dorsal portion of the central parenchyma unite to form the *vas deferens* (*v. def.*, figs. 75, 80) which passes laterad near the anterior border of the segment, in the direction of the genital pore. Before reaching the cirrus pouch, however, the vas deferens is dilated to form a large pyriform *seminal vesicle* (*ves. sem.*, figs. 75, 80, 82).

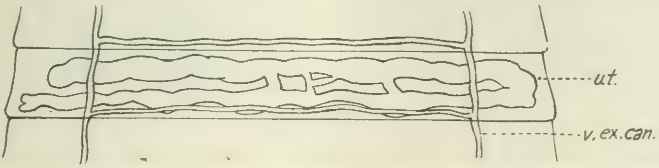
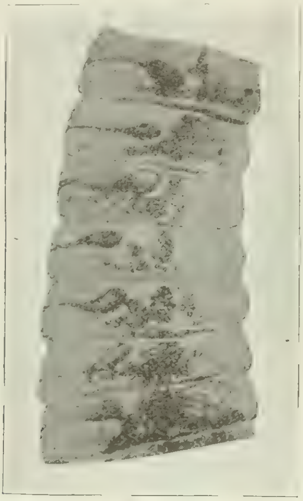


FIG. 84.—Longitudinal section of proglottid of *H. diminuta* showing the arrangement of the uterus: *ut.*, uterus; *v. ex. can.*, ventral lateral excretory canal. Enlarged. (After Zschokke, 1889, pl. 2, fig. 24.)

The *cirrus pouch* (*c. p.*, figs. 75, 80) is claviform and well supplied with circular and longitudinal muscle fibers. Fibers directed in an oblique or spiral direction are also often apparent. The vas deferens within the cirrus pouch is supplied with muscle fibers; it becomes narrow and forms the slender *cirrus*, an organ bent and twisted when in a state of retraction, but which may be straightened and extended through the genital pore a distance of 50 to 60 μ. In sections the cirrus is occasionally seen protracted and entered for a considerable distance into the vagina of the same segment.

After they have fulfilled their function, the testes degenerate, but traces of them are often distinguishable even in the oldest segments (*t.*, fig. 83). After it once reaches maturity the cirrus pouch continues with little apparent change to the end of the strobila.

Female organs.—The *vagina* (*vag.*, figs. 76, 80) opens into the genital pore on the ventral side of the cirrus pouch. It soon dilates into a large, elongated, and very prominent *seminal receptacle* (*rec. sem.*, figs. 76, 80–83) which extends inward nearly to the middle line. It is this organ filled with sperm which appears as the yellow spot, and furnished the name *flavopunctata* of Weinland. Weinland erroneously interpreted this organ as a testis.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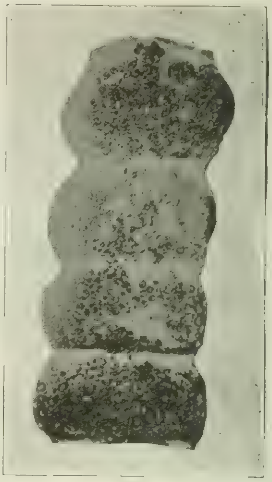
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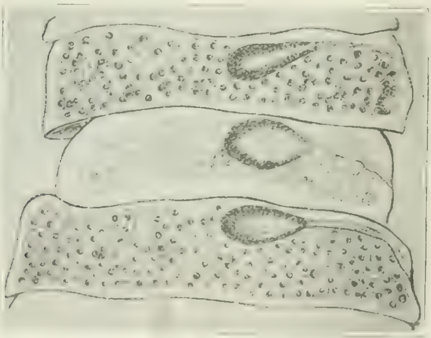
FIG. 85.—Immature proglottids of *H. diminuta*. Enlarged. (After Stein, 1882, pl. 13, fig. 10.)
FIG. 86.—Gravid proglottids of *H. diminuta*. Enlarged. (After Stein, 1882, pl. 13, fig. 11.)

Near the middle of the segment the seminal receptacle ends and opens into the middle of the *oviduct* by a narrow tube (fig. 81).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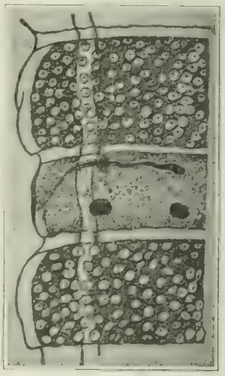
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FIG. 87.—Gravid proglottids of *H. diminuta* (one sterile). Enlarged. (After Leuckart, 1863, p. 399, fig. 117.)
FIG. 88.—One-half of two fertile joints of *H. diminuta*, with that of an intervening sterile joint. Enlarged. (After Leidy, 1884a, p. 113.)

The *ovary* (*ov.*, figs. 76, 80, 82) is more or less bilobed and situated in the median part of the proglottis. The *oviduct* (*ovd.*, figs. 80, 81) leading from the ovary runs first forward, is joined by the narrow tube from the seminal receptacle, then turns toward the ventral surface and backward, and in the midst of the complex of cells, known as the shell gland, is joined by the duct from the yolk gland. The *shell gland* (*s. g.*, figs. 80, 81) is a little rounded mass which lies between the right and left lobes of the ovary. The *yolk gland* (*y. g.*, figs. 76, 80–82) is lenticular in shape and situated on the ventral side of the shell gland and somewhat more posteriorly. With respect to the main body of the ovary the yolk and shell glands are posterior (caudad).

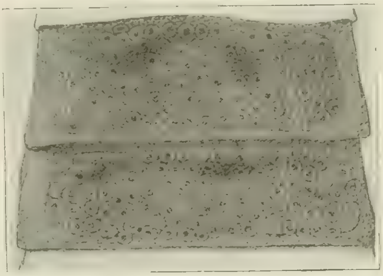


Fig. 89.—Proglottids of *H. diminuta* from posterior portion of strobila. Enlarged. (After E. Parona, 1884, fig. 7.)

From its point of union in the shell gland with the yolk duct the oviduct turns forward and empties into the *uterus* on the dorsal side of the anterior part of the ovary (figs. 80, 81). The uterus at first is simply a transversely elongated mass of cells without a cavity, but as it develops becomes hollowed out and the tube thus formed grows in various directions, sending out diverticula and increasing in size generally so as to gradually fill up practically the entire proglottis. After the uterus begins to grow actively the ovary quickly disappears. The yoke gland, however, remains apparent for a long time. According to the degree of development which the uterus has reached it is evident that the appearances will be somewhat different. Zschokke (1889), for example, has described a condition (fig. 84) in which the uterus has the form of two transverse canals uniting at one side so as to form a loop, the two limbs of which are also connected at various other points. Grassi (1888) noticed in sections of segments in which the uterus had not reached its final development, that it appeared as a large number of cavities of various sizes communicating with one another (figs. 82, 83).

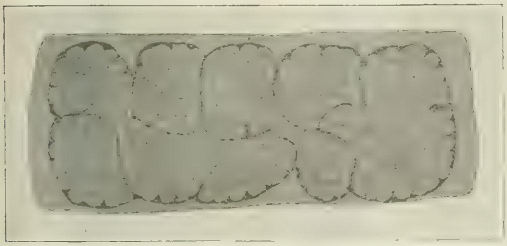
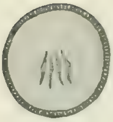


Fig. 90.—Proglottis of *H. diminuta* containing fully developed ova, rendered transparent with potash. Enlarged. (After Grassi, 1888, pl. 11, fig. 15.)

As the uterus grows the diverticula become crowded together, and the eggs form a more or less compact mass occupying nearly the whole segment. The adult uterus, at first sight apparently a simple sac filled with eggs, is thus seen to be more complex; its cavity, although continuous, is broken up by incomplete partitions, and by innumerable processes invaginated from its walls, penetrating everywhere among the eggs as in *Hymenolepis nana*, but in this case more pronounced, so that



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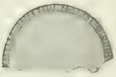

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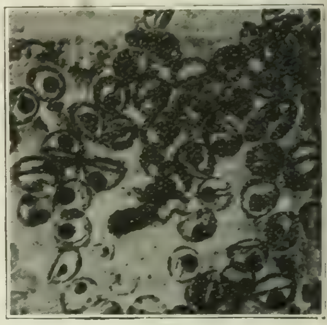

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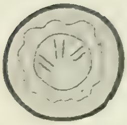

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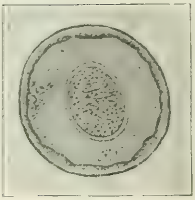

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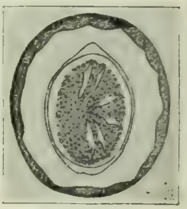

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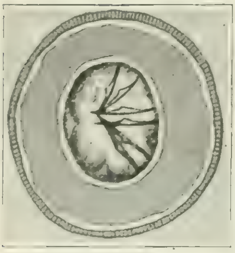

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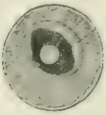

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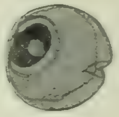

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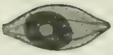

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FIG. 91.—Egg of *H. diminuta* from the woodmouse (*Mus sylvaticus*). Median focus. Enlarged. (After Dujardin, 1845a, pl. 12, fig. G1.)

FIG. 92.—Egg of *H. diminuta* from the woodmouse (*Mus sylvaticus*). Superficial focus. Enlarged. (After Dujardin, 1845a, pl. 12, fig. G2.)

FIG. 93.—Eggs of *H. diminuta* from man. Enlarged. (After Stein, 1882, pl. 13, fig. 12.)

FIG. 94.—Egg of *H. diminuta* from rat. Enlarged. (After Zschokke, 1889, pl. 2, fig. 30.

FIG. 95.—Egg of *H. diminuta* from man, as seen in feces. Enlarged. (After Grassi, 1888l, pl. 11, fig. 16.)

FIG. 96.—Egg of *H. diminuta* from man, as seen in feces. Enlarged. (After Grassi, 1888l, pl. 11, fig. 17.)

FIG. 97.—Egg of *H. diminuta* from man. E. Parona's (1884) case. Enlarged. (After Bizzozero, [illegible], pl. 1, fig. 8.)

FIG. 98.—Egg of *H. diminuta* from man. Enlarged. (After Weinland, 1861, pl. 4, fig. 12.)

FIG. 99.—Fully developed egg of *H. diminuta* from man, with outer membrane broken and intermediate substance protruding. Enlarged. (After Weinland, 1861, pl. 4, fig. 13.)

FIG. 100.—Egg of *H. diminuta* in glycerin; outer membrane folded. Enlarged. (After Weinland, 1861, pl. 4, fig. 14.)

FIG. 101.—Embryo of *H. diminuta* surrounded by inner membrane. Outer membrane and intermediate substance have been torn away. Enlarged. (After Weinland, 1861, pl. 4, fig. 15.)

the result may be compared to a sponge, the meshes of which are filled by the eggs (figs. 87–90).

In *Hymenolepis diminuta* from man it is a very common thing to find numerous sterile proglottids (figs. 87, 88). In these segments the female organs fail to develop properly, and no embryos are produced. Such segments are readily apparent in the older portions of the strobila, by reason of their clear color, due to the absence of eggs, which give fertile segments a somewhat dark or brownish color. These sterile segments have been noticed by nearly everyone who has ever observed *H. diminuta* from man, while in specimens from the rat they are much less common. Leidy (1884a), for example, gives the following succession of fertile and sterile segments in a fragment about 8 cm. long. The fertile segments are indicated by roman type, the sterile by italics:

2, 1, *2*, 1, *6*, 1, *1*, 1, *5*, 1, *18*, 1, *3*, 1, *3*, 5, *1*, 1, *3*, 4, *1*, 1, *3*, 1, *1*, 5, *2*, 7, *1*, 10, *1*, 6, *3*, 3, *15*, 1, *2*, 2, *2*, 2.

Eggs.—The eggs as first seen in the uterus do not differ apparently from the eggs as found in the ovary. The shell is not formed by the immediate action of the so-called shell gland, as might be supposed, during the passage of the egg through the part of the oviduct surrounded by this gland, but only becomes apparent during the progress of the development of the embryos in the uterus. When fully formed the embryo possesses a shell in which 3 layers may be distinguished, an *outer*, a *middle*, and an *inner* (figs. 91–101). Both the embryo and its shell increase in size after development is begun, until the final stage of the eggs as they are thrown off in the feces is reached. The egg as seen in the feces or in the oldest segments is spherical (figs. 91–95, 97). The *outer membrane* is comparatively thick and delicately striated radially, and is more or less yellowish in color. The *inner membrane* closely invests the embryo or onchosphere and is somewhat oval in shape, often with two polar papillæ (fig. 96), as in *Hymenolepis nana*, but so far as is known without filaments. This membrane is thinner than the outer. Between the outer and inner membranes is an intermediate layer of granular structure, apparently albuminous in character.

When the outer envelope is broken away (fig. 99), this intermediate layer remains and is seen to have a smooth external contour, as though limited by a very thin but distinct membrane. In sections of preserved material this granular intermediate layer is commonly found drawn away from both the outer and inner envelopes, and bounded internally and externally by a very delicate smooth membrane of chitinous appearance. In the granular mass are three or four or more prominent deeply staining nuclei. It is to the activity of these nuclei, or of the cells to which they belong, that the formation and growth of the shell of the embryo seem to be due.

It is only in eggs of the oldest segments that the radial structure of the outer membrane can be distinguished: in eggs of younger segments this striation is not apparent, and the membrane is much thinner. In still younger segments the eggs are considerably smaller and the shape is commonly oval.

A number of authors give the sizes of the eggs as follows:

Dujardin (1845a, p. 579): Outer envelope, 62 to 74 μ; inner envelope, 41 to 42 μ; embryo, 32 to 36 μ; hooks, 15 to 17 μ.

Weinland (1858, p. 55): Outer envelope, 54 μ; embryo, 24 μ.

Leuckart (1886a, pp. 661-663, from Weinland's material): Outer envelope, 60 μ; embryo, 30 μ; hooks, 17 μ.

E. Parona (1884): Outer envelope, 58 to 68 μ.

Grassi (1888l): Outer envelope, 70 to 86 μ; embryo, 36 by 28 μ; hooks, 11 μ.

Zschokke (1889), no measurements given.

Leidy (1884a, p. 110): Outer envelope, 72 μ; a few oval eggs 80 by 72 μ; embryos, 40 by 32 μ.

Magalhães (1896): Outer envelope, about 59.5 μ; embryo, about 34 μ.

Sonsino (Sonsino & Zschokke, 1896): Outer envelope, 75 μ and 80 by 75 μ; hooks, 14 μ.

In measurements which I have made of eggs of specimens, both from the rat and from man (Leidy's material), the outer envelope ranged, in both cases, from 64 to 80 μ; the inner, 24 by 20 μ to 36 by 28 μ; the hooks, 14 to 16 μ.

The middle pair of hooks differed from the other two pairs in the same manner as mentioned above in connection with *H. nana*, namely, they were more delicate and the ventral root was only very slightly developed.

Besides the eggs of ordinary size it is not uncommon to find in mature segments now and then an egg considerably smaller, round or slightly oval, with the outer envelope much thicker than is usual in the larger eggs. Four such specimens gave sizes ranging from 40 by 40 μ to 40 by 48 μ.

Sonsino (Sonsino & Zschokke, 1896, p. 939) has found that the ova will remain alive in water at least fifteen days.

DEVELOPMENT AND LIFE HISTORY.

It is to the observations of Grassi & Rovelli (1888b, 1889a, 1889b, 1892a) that we owe our knowledge of the life history of *Hymenolepis diminuta*. Their results (as given in Grassi & Rovelli, 1892a, pp. 31–33, 90–92) are as follows:

All attempts at direct infestation resulted negatively.

The cysticercoids were first found in the larva of the meal moth and its adult (*Asopia farinalis*), then in young and adult earwigs (*Anisolabis annulipes* Lucas), and finally in adults of beetles (*Acis spinosa* (Linnaeus) and *Scaurus striatus* (Fabricius). They live in the abdominal cavity of these various insects amid the adipose tissue, sometimes in very considerable numbers.

The larva of *Asopia farinalis* is very common in dwelling houses all over Europe, where it feeds upon organic materials, refuse, flour, meal, etc. In the moth stage it is frequent in April and October. This moth is also common in America, and, in fact, is almost cosmopolitan in its distribution.

On account of its wide geographical range corresponding with the distribution of *H. diminuta*, Grassi considers that *Asopia* is probably the normal intermediate host of the tapeworm in question. It is said by Grassi that rats prey actively not only upon the larval, but also upon the adult moths.

Acis spinosa lives in the south of Europe, *Scaurus striatus* in the south of France, in Italy, Spain, and Greece; both belong to the same family of beetles (Tenebrionidæ), related to that in which *Tenebrio* belongs, the latter, the supposed intermediate host of *Tænia microstoma*.

Twenty or more cysticercoids from *Anisolabis* were administered to white rats, which were entirely free from tapeworms; after 3 days the head of *H. diminuta* with a very short neck was observed in the intestine; after a week the neck had become longer, ½ cm., with no trace of segments; in 15 days the worm had become quite long but without yet having reached maturity. The experiments were repeated for all the other intermediate hosts; the results were constantly positive, and the adult worms obtained corresponded perfectly to *H. diminuta*.

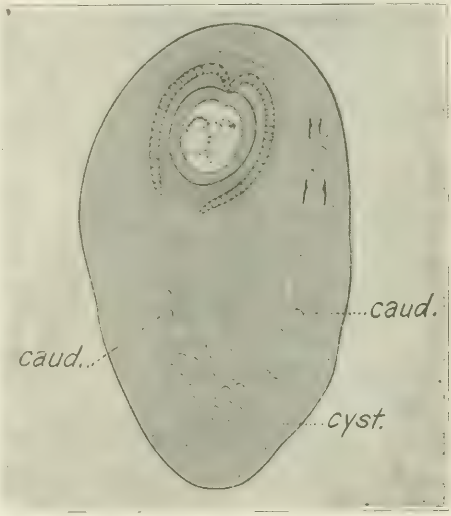


Fig. 102.—Encysted cercocystis of *H. diminuta*: *caud.*, caudal appendage; *cyst.*, adventitious capsule inclosing the cercocystis. Enlarged. (After Grassi & Rovelli, 1892a, pl. 4, fig. 1.)

Two experiments were tried on man, one upon Sig. Calandruccio, which resulted negatively, and one upon a second individual (adult male); in the second case, 15 days after the ingestion of the cysticercoids (from *Acis spinosa*), the ova of *H. diminuta* appeared in the feces, and after treatment with male fern, numerous specimens of the tapeworm were passed.

The *cysticercoid* was observed only in the mature stage, free or provided with an adventitious connective tissue capsule, evidently derived from the host. Its size is measured by a few tenths of a millimeter. Like the cysticercoid of *Hymenolepis nana*, it has a body and a tail, and may therefore be termed a cercocystis. The tail is rather long, two or three times the length of the body (fig. 102). As in the case also of *H. nana* (see p. 40) the body is a gastrula-like structure, with an anterior opening and a secondary cavity formed by invagination. Likewise, a very thin primary cavity separates the outer and the inner wall. The two walls are highly differentiated (figs. 103, 104). The outer consists, proceeding in the order from without inward, of a thick cuticula striated radially, a layer of fusiform, somewhat cylindrical cells, a layer of circular fibers (muscular?), a layer of cells much elongated longitudinally, and finally a lamellar layer. The second layer is not complete, but forms two longitudinal bands on opposite sides of the body. In cross section the body is seen to be rather oval, with these two bands of cells, cut across, corresponding to the poles of the major axis of the ellipse (fig. 104). The inner wall is composed of a layer of reticular connective tissue, rich in cells and calcareous corpuscles, and lined with cuticula. The relations of the scolex are the same as in the cercocystis of *H. nana* (see p. 40); that is, it lies within the second cavity, and is attached behind to the inner wall by a peduncle, which in this case, however, is thicker and shorter than in *H. nana*. The primitive cavity is well defined in good preparations; it does not extend into the tail. The anterior opening of the secondary cavity is very narrow and deep. The four excretory vessels form horseshoe-like loops in the scolex in relation with the inner wall (fig. 106).

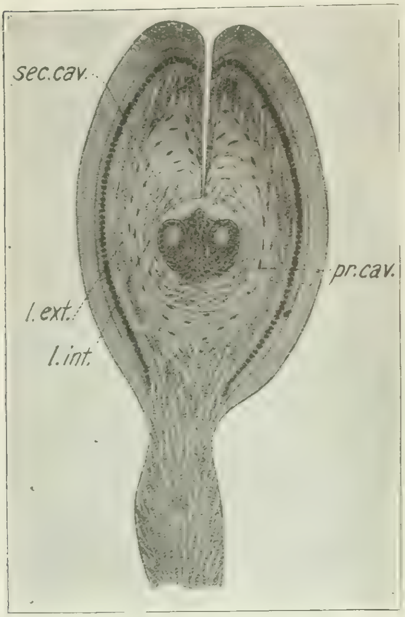


FIG. 103.—Longitudinal section of cercocystis of *H. diminuta*: *l. ext.*, external wall; *l. int.*, internal wall; *pr. cav.*, primary cavity; *sec. cav.*, secondary cavity. Enlarged. (After Grassi & Rovelli, 1892a, pl. 4, fig. 3.)

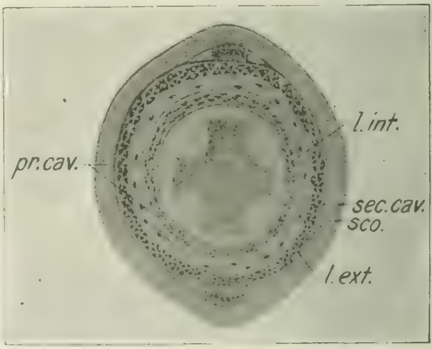
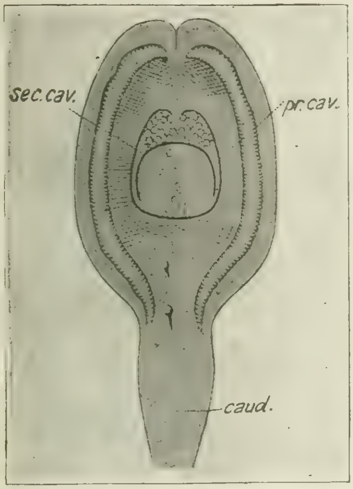


FIG. 104.—Cross section of cercocystis of *H. diminuta*: *l. ext.*, external wall; *l. int.*, internal wall; *pr. cav.*, primary cavity; *sco.*, scolex; *sec. cav.*, secondary cavity. Enlarged. (After Grassi & Rovelli, 1892a, pl. 4, fig. 2.

The embryonal hooks are frequently evident, commonly four upon the tail and two upon the most posterior part of the body proper (fig. 105).

Since the tail was sometimes found branched and at other times (in *Anisolabis*) the cysticercoids were united by their tails into groups of 3 or 4, and since occasionally in *Acis spinosa* a smaller cysticercoid would be found attached by the tip of the tail to the thickest part of the tail of a cysticercoid of ordinary size, it seemed probable to Grassi that in certain cases the cysticercoid of *H. diminuta* is capable of proliferation.



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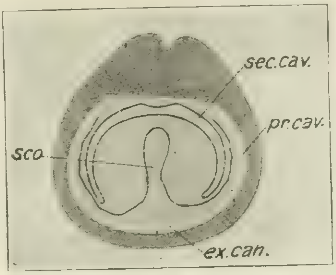

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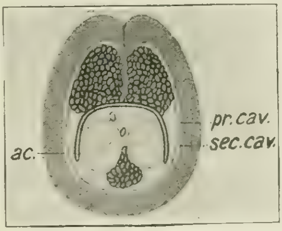


107.

FIG. 105.—View of cercocystis of *H. diminuta*, showing muscle fibres: *caud.*, caudal appendage: *pr. cav.*, primary cavity; *sec. cav.*, secondary cavity. Enlarged. (After Grassi & Rovelli, 1892a, pl. 4, fig. 4.

FIG. 106.—Longitudinal section through the body of a cercocystis of *H. diminuta*: *ex. can.*, exeretory canal; *pr. cav.*, primary cavity; *sec. cav.*, secondary cavity. Enlarged. (After Grassi & Rovelli, 1892a, pl. 4, fig. 6.)

FIG. 107.—Longitudinal section through the body of a cercocystis of *H. diminuta*: *ac.*, sucker; *pr. cav.*, primary cavity; *sec. cav.*, secondary cavity. Enlarged. (After Grassi & Rovelli, 1892a, pl. 4, fig. 5.)

Cysticercoids, single or proliferated, were often found dead, having undergone a degeneration by which they became brown, and the details of structure indistinct. In some cases, in *Acis spinosa*, the adventitious capsule was present and very thick; live cysticercoids were found encapsulated in *Anisolabis*.

In a footnote (Grassi & Rovelli, 1892a, p. 33) it is stated that more recently a stage in the development of the cysticercoid was found which showed that in *H. diminuta* the formation of the rostellum and suckers precedes the invagination as in *Hymenolepis nana*.

ABSTRACTS OF CASES OF HYMENOLEPIS DIMINUTA IN MAN.

AMERICA.

Boston, 1842 .... 1 case.

Weinland (1858) was the first to record the occurrence of this tapeworm in man. His account (1858, p. 59) in part reads as follows:

"Among the helminthological specimens with which Dr. J. B. S. Jackson kindly furnished us for further investigation, from the collection of the Medical Improvement Society, Boston, there was a phial containing a number of pieces of a small tapeworm. In the catalogue of the collection we find these specimens mentioned under No. 903, with the following words: 'A (second) specimen of *Bothriocephalus*, 3 feet in length, and from ½ line to 1¼ lines in width; from an infant. The joints are very regular, except at one extremity, where they approach the triangular form, are very delicate, and but slightly connected, as shown in a drawing by Doctor Wyman. From a very healthy infant 19 months old; it had been weaned about six months, and had had the usual diet from that time. The worm was discharged without medicine, its presence having never been suspected. 1842. Dr. Ezra Palmer, jr.' "

Weinland recognized the fact that this specimen was not a *Bothriocephalus*, but a tapeworm belonging "to a group of Tæniods, whose members thus far had only been found in small omnivorous or insectivorous mammalia (mice, shrew-mice, etc.) and birds." Not perceiving its identity with *Tænia diminuta*, he accordingly described it as a new species, at the same time establishing it as the representative of a new genus, and gave it the name of *Hymenolepis flavopunctata* (see p. 82).

Philadelphia, Pa., 1884 .... 1 case.

Leidy (1884a, p. 110, 1884b, p. 137) recorded a case of *Tænia flavopunctata* (=*Hymenolepis diminuta*) from a 3-year-old child, who had expelled several pieces of at least 3 worms after treatment with santonin. This child, native of Philadelphia but of German parentage, had been weaned at 20 months, and since then partaken of the same food as its parents. The specimens from this case are preserved in the Helminthological Collection (No. 841) of the Bureau of Animal Industry.

São Paulo, Brazil, 1893 .... 1 case.

Lutz (1894, p. 62) received a tapeworm for determination which had been passed after treatment with santonin, by a 2-year-old child, daughter of Portuguese settlers, living at São Paulo, Brazil. The specimen had about 960 segments, several of which were sterile; the posterior segments were completely filled with eggs, and the rostellum was rudimentary and unarmed. Lutz identified it as *Hymenolepis diminuta*, and by comparison with specimens from the rat confirmed Grassi's observations as to the identity of *Tænia flavopunctata* of man and *Tænia diminuta* of the rat. The parasite is very common among the rats of São Paulo.

Rio Janiero, Brazil, 1896 .... 1 case.

The patient in this case (Magalhães, 1896) was a mulatto child, 20 months old, born in a neighboring city, but for about a year living in Rio Janiero, at the zoological gardens, where her father was employed. The child had been suffering for about 3 months with diarrhea, frequently sanguineous in character. Treatment by various physicians was of no avail. According to the parents, the child's food consisted exclusively of milk and beef tea. After the administration of a dose of calomel a worm was passed, which was referred by the attending physician to Magalhaes for determination, who identified it as *Hymenolepis diminuta*. The child's parents asserted that a similar worm, somewhat longer, and also fragments, had been passed previously. The child continued to suffer with diarrhea. Treatment with male fern was tried; no worms were expelled, and the diarrhea still persisted, ceasing at times, but always recurring. Later an *Ascaris* was passed, without improvement of the diarrhea.

Philadelphia, Pa., 1900 .... 1 case.

PACKARD (1900, p. 1551) describes the case of a woman, 40 years of age, native of Syria, who entered the Pennsylvania Hospital at Philadelphia, suffering with a hydatid cyst of the liver, from which she died. Shortly after admission she passed a fragment of a tapeworm 16.5 cm. long. The segments were 3 mm. wide by 1 mm. long. At the autopsy, about one month after the patient entered the hospital, a second specimen was found, attached to the intestine about 2.5 cm. above the ileocecal valve. The parasite was living when found and measured 27 cm. in length. The head was distinctly blackish in color, with a slight purple tinge, and measured 1 mm. long by 0.5 mm. wide. The neck was 1 cm. long and 1.5 mm. wide. "In most of the segments there is seen at one edge a little elevation extending in from the edge about 1 mm., corresponding apparently to what has been spoken of in some specimens as the yellow spot. These little elevations do not form a complete series, as occasionally there is found a segment where the elevation is on the opposite side of the segment. There is no appearance about the worm of a true yellow spot. On dehydrating segments in absolute alcohol and clearing in oil of cloves there is seen in each of a series of 7 segments a dark line less than $\frac{1}{10}$ of a millimeter in thickness extending inward toward the center of the segment to a length of 3 mm." There was no branching uterus, the entire proglottis being transformed into an egg-sac. The brownish line extended inward from the left side in 5 segments, from the right side in 2, as follows: l, r, l, r, l, l, l. Viewed under a high power, the brownish line was seen to be a canal, sometimes appearing to terminate in a bulbous enlargement.

EUROPE.

Alfort, France, before 1810 .... 1 case.

RAILLIET (1892c) makes mention of two fragments of a tapeworm, measuring together 18 to 20 cm. in length, and a number of fragments belonging to a second example. These specimens, which were labeled as coming from man, belong to an old helminthological collection established by Chabert, second director (1780–1810) of the museum at Alfort. Rudolphi visited this collection about the year 1804, and since he has made no mention of such specimens in any of his works on helminthology, Railliet has come to the conclusion that they probably date from a time between 1804 and 1810. These specimens were determined by both Railliet and Zschokke as *Hymenolepis diminuta.*

Varese, Italy, 1884 .... 1 case.

A 2-year-old girl living in the neighborhood of Varese had declined in health and lost her usual good spirits. Pieces of tapeworm having been recognized in her stools, she was brought to the hospital of Varese for treatment. E. PARONA (1884), who examined the case, found no abnormalities of importance in the physical examination. The feces contained the eggs of *Ascaris* and cestode eggs resembling those of *Tænia solium* but much larger. Castor oil and ethereal extract of male fern were administered and 4 complete worms, 12 to 20 cm. long, each provided with a head, were passed. Treatment was repeated, but no more worms, with the exception of an *Ascaris*, were expelled. Parona considered these worms probable examples of *Hymenolepis flavopunctata* Weinland, a determination which Grassi (1888l) confirmed after examining some of the material.

Catania, Sicily, 1887–1888 .... 2 cases.

GRASSI (1888l, p. 498, GRASSI & ROVELLI, 1888b) records a case of *Hymenolepis diminuta* from a 12-year-old girl, who exhibited no symptoms of importance. After anthelmintic treatment, she passed, besides a *Tænia solium*, 2 specimens of *Hymenolepis diminuta*, measuring 25 and 30 cm., one of which possessed a head.

In the second case (Grassi, 1888, p. 500, Grassi & Rovelli, 1888b) infection was induced experimentally by feeding a man with cysticercoids (see p. 95).

Pisa, Italy, 1895 -- **1 case.**

A specimen of tapeworm, which had been passed by a boy in September, 1895, after the administration of an anthelmintic, was referred to Sonsino (Sonsino & Zschokke, 1896) for determination by Doctor Modigliano, of the Pisa hospital. Sonsino determined the specimen as *Tænia flavopunctata* Weinland (=*H. diminuta*). Zschokke made a similar determination. The description of the worm and the figure of an egg given by Sonsino leave no doubt as to its identity.

Centuripe, Sicily, 1900 -- **2 cases.**

Previtera (1900) discovered in the feces of sulphur miners in Sicily the eggs of a tapeworm, undoubtedly of the species *Hymenolepis diminuta*.

The first case was that of a sulphur miner, male, 11 years old. There was an average of one egg in every preparation. The eggs were mostly spherical, almost double the size of eggs of *Tænia solium;* two membranes were present, separated by an abundant hyaline substance which shriveled in glycerine and drew away from the outer membrane; the latter was distinctly striated radially; some of the eggs were uncolored, some yellowish. Male fern was administered. Whether any worms were passed is not known, but a reëxamination of the feces some days later showed no eggs present.

In the feces from the other case 2 to 3 eggs were found in every preparation. The subject of this case was not seen, nor was any information regarding his age, physical condition, etc., obtainable.

ANALYSIS OF CASES.

AGE AND SEX OF INDIVIDUALS AFFECTED.

Of the 12 cases reported, 5 were females, 3 were males, while the sex of the remaining 4 cases is not given. Two were adults, one of whom was a woman, 40 years of age; 8 were children, and the ages of 2 were not given. Four were between 1½ and 2 years; 1 was 3 years, and 2 were 11 and 12 years, respectively; the age of the other child was not given.

SITUATION OF THE PARASITE IN THE INTESTINE.

In the single autopsy which has been performed (Packard, 1900) the worm was found attached 2.5 cm. above the ileo-cecal valve.

NUMBER OF SPECIMENS PRESENT.

The number of specimens present in infected individuals has varied from 1 to 4. In 4 cases there was 1; in 3 cases, 2; in 1 case, 3; and in 1 case, 4.

OTHER PARASITES PRESENT.

In 2 cases the presence of *Ascaris* and in 1 case the presence of *Tænia solium* was noted; 1 case was suffering with a hydatid cyst of the liver.

SYMPTOMATOLOGY.

Symptoms were absent in practically all the cases; in one case there was said to be a decline in health and in another there was a diarrhea of three months' standing, which, however, was not cured by the expulsion of the parasite.

DIAGNOSIS.

The diagnosis rests upon the discovery of fragments of the worm or its eggs in the feces.

TREATMENT.

Almost any vermifuge seems to be sufficient to expel the parasite. A simple cathartic has caused its expulsion, and in one case the worm was passed without medicine.

PROPHYLAXIS.

Prophylaxis against *H. diminuta* consists in avoiding the ingestion of any of the various insects which may act as intermediate hosts, (1) by following the general rule of cleanliness with regard to what is placed in the mouth, (2) by keeping food protected from insects, especially the larvæ of *Asopia farinalis*, and (3) the destruction of rats and mice, and of the insects concerned, especially the meal moth, which in its larval stages is common about dwellings.

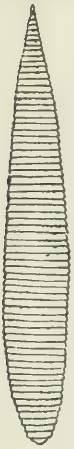
The Lanceolate Tapeworm—HYMENOLEPIS LANCEOLATA (Bloch, 1782) Weinland, 1858.

HISTORICAL REVIEW.

This tapeworm has long been known as a parasite of geese and ducks, but only recently has it been found in man. An epidemic of intestinal helminthiasis among geese in 1710 in Germany reported by Frisch (1727b) has been attributed to this form. Bloch (1779a), according to Rudolphi (1810, p. 84), refers to the worm under the name *Tænia anseris*. Pallas (1781) associated the worm under consideration with others from rabbits and fishes, and placed them in a single species, which he called *Tænia acutissima*. In 1782 Bloch published the first distinctive description and figures (figs. 108, 109) of the worm, calling it *Tænia lanceolata*. Goeze (1782a) shortly afterwards described and figured it (fig. 110) under the same name. Since then it has been commonly found in the European countries by various authors, but apparently has never been recorded for America. Only one case of *Hymenolepis lanceolata* in man has been reported, and that case was in Europe (Zschokke, 1902a, b). It is, therefore, a rare parasite of man, and is not very likely to be encountered in this country.

ANATOMICAL DESCRIPTION.

The external characteristics of *Hymenolepis lanceolata* are so well marked that its recognition has never been considered difficult. Feuereisen (1868a) was the first to study its internal anatomy; his incomplete and in some respects incorrect description has recently been revised and added to by Wolffhügel (1900b) and Cohn (1901b).



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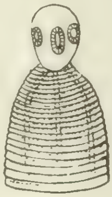

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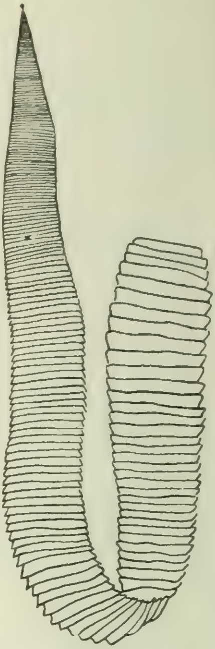

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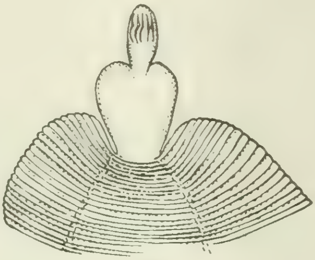

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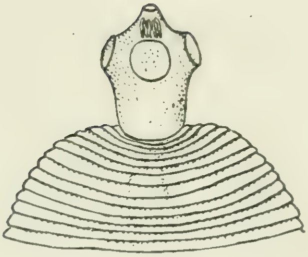

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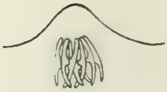

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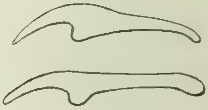

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Fig. 108.—Head and strobila of *H. lanceolata*. Natural size. Original type figure. (After Bloch, 1782a, pl. 1, fig. 5.)

Fig. 109.—Head and anterior portion of *H. lanceolata*. Enlarged. Original type figure. (After Bloch, 1782a, pl. 1, fig. 6.

Fig. 110.—Head and strobila of *H. lanceolata* from a goose. Natural size. (After Goeze, 1782a, pl. 29, fig. 3.

Fig. 111. Head with protracted rostellum and anterior portion of *H. lanceolata*. Enlarged. (After Megnin, 1881, pl. 4, fig. 3.

Fig. 112.—Head with retracted rostellum and anterior portion of *H. lanceolata*. Enlarged. (After Railliet, 1886, p. 267, fig. 163A, also Railliet, 1893, p. 300, fig. 195A.)

Fig. 113.—The eight hooks upon the rostellum of *H. lanceolata*. Enlarged. (After Krabbe, 1869, pl. 6, fig. 143.

Fig. 114.—Two isolated hooks of *H. lanceolata*. Enlarged. (After Krabbe, 1869, pl. 6, fig. 144.)

EXTERNAL ANATOMY.

The length has been given as 30 to 130 mm.; the width posteriorly may attain a maximum of 18 mm., more commonly 7 to 12 mm. The *strobila* gradually increases in width from before backward, reaching its greatest width a short distance anterior of the posterior extremity, then becomes narrower again and rounded off posteriorily, thus giving the worm its characteristic lancet shape (figs. 108, 110). In the anterior portion of the strobila the segments are 30 to 35 times as broad as long; in segments with mature reproductive organs the ratio between length and breadth is 1 to 40; in the last segments, 1 to 25. The *head* (figs. 111, 112), which is very small in comparison to the rest of the worm, possesses a retractile *rostellum* armed with a single crown of hooks, usually 8 in number (fig. 113). The *hooks* (fig. 114) have a long dorsal root, a short ventral root, and a prong equal in length to about two-thirds of the dorsal root. They measure 31 to 35 μ (Krabbe, 1869). The short *neck*, together with the head, is often retracted into the anterior part of the strobila. The *segments*, about 300 in number, in specimens 85 or 90 mm. in length (Zschokke, 1902a, b), are very much broader than long throughout the strobila. The *genital pores* open on the right-hand margin of the strobila, near the anterior border of each segment.[a]

INTERNAL ANATOMY.

The internal anatomy of the head has not been studied.

Calcareous bodies are numerous, especially in the cortical parenchyma.

NERVOUS SYSTEM.—The lateral *longitudinal nerves* are situated laterad of the longitudinal excretory vessels; each main lateral nerve is accompanied by two accessory nerves—one dorsal and one ventral (fig. 117).

MUSCULAR SYSTEM.—The usual subcuticular muscle fibers are present, an *outer circular* and an *inner longitudinal layer*. *Dorso-ventral muscle fibers* likewise are present, and are very powerfully developed.

The well-developed *longitudinal muscle* system (*l. m.*, fig. 121) is arranged mostly in two layers, with about 90 to 100 (Wolffhügel, 1900b) or 200 (Zschokke, 1902a, b) bundles in each layer. In the cortical parenchyma, i. e., between the outer muscle layer and the cuticula, there are numerous scattering longitudinal muscle fibers. Lying inside the inner layer in both the dorsal and the ventral halves of the strobila there are two bundles of muscle fibers, one on each side of the median line, separated by a space equal to about one-sixth the

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[a] Dujardin (1845a, p. 562) describes the pores of *Tænia lanceolata* as irregularly alternate, mentioning also the presence of 10 hooks on the rostellum; two circumstances which indicate the probability that he had under observation another species.

breadth of the strobila (Wolffhügel, 1900b). Wolffhügel found that the two longitudinal muscle layers become more or less fused in the older segments so that they can no longer be distinguished as separate. Cohn (1901b, p. 320) asserts that the layers in question can not be considered individually distinct at all, as they nowhere preserve their identity for any considerable distance. He also differs with Wolffhügel in that he failed to find the four isolated bundles described by the latter author. Zschokke (1902a, b) has noticed numerous diagonal fibers connecting here and there the bundles of longitudinal fibers.

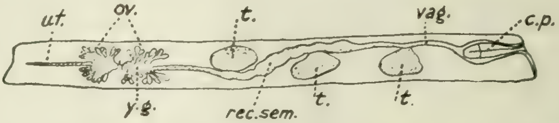


Fig. 115.—Isolated proglottid of *H. lanceolata: c. p.*, cirrus pouch; *ov.*, ovary; *rec. sem.*, receptaculum seminis; *t.*, testis; *ut.*, probably the primordium of the uterus; *vag.*, vagina. Enlarged. (After Feuereisen, 1868a, pl. 10, fig. 17.)

Excretory system.—There are two pairs of lateral longitudinal excretory vessels, of which the ventral pair are the larger (fig. 117). According to Wolffhügel (1900b) transverse canals connecting the longitudinal vessels are lacking, but Cohn (1901b) has found a system of small anastomosing canals extending across the posterior portion of each segment, connecting the longitudinal canals and taking the place of the transverse canals. The excretory vessels and the lateral longitudinal nerves pass on the ventral side of the cirrus pouch.

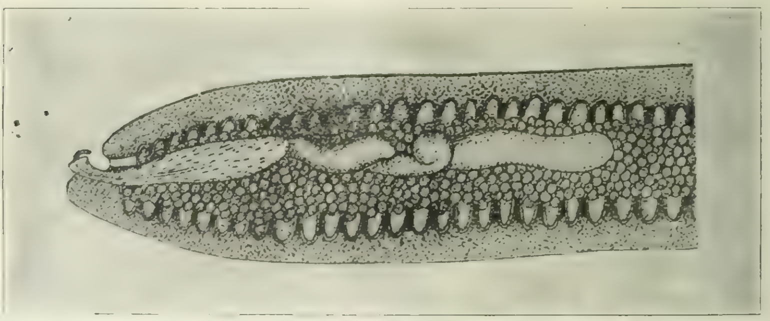


Fig. 116.—Transverse section of proglottid of *H. lanceolata.* Enlarged. (After Mégnin, 1881, pl. 4, fig. 6.)

Reproductive system.—The reproductive organs lie in the central portion of the parenchyma, i. e., inside of the longitudinal muscle layer, and are so distributed that the female glands occupy the sinistral third of the proglottis; the three testes and a portion of the seminal receptacle the middle third; and the remainder of the seminal receptacle, the vagina (*sensu stricto*), the seminal vesicle and the cirrus pouch, the dextral third (figs. 115, 117).

Male organs.—The three *testes* (*t.*, figs. 115, 117) are oval, with their long axes directed parallel to the transverse axis of the segment, and occupy almost the entire thickness of the inner parenchyma. The two dextral testes are in the posterior half, the other one in the anterior half of the proglottis.

The *vas deferens* (*v. def.*, fig. 117) in its course to the genital pore lies toward the dorsal side of the segment; after passing the right hand testis it swells out into a large *seminal vesicle* (*ves. sem. ex.*, fig. 117) then somewhat reduced again in size describes one or two S-shaped loops, and enters the base of the *cirrus pouch.*

The latter (*c. p.*, figs. 115, 117) is a powerfully developed club-shaped organ, which when straight lies entirely in the anterior half of the proglottis; it may be bent S-like and lie in the posterior half of the proglottis as well. It measures in length from 0.82 to 1.2 mm. and from 60 to 190μ in width at different points. Externally the cirrus pouch (fig. 121) is supplied with a layer of longitudinal muscle lamellæ (*m. pl.*) which has a maximal thickness of 50μ. The lamellæ become gradually thinner toward the distal end of the cirrus pouch, and in its outer third are reduced to a very thin muscle layer. In relation to the muscle lamellæ is a thick layer of myoblastic cells (*my.*). Within the cirrus pouch the vas deferens is again enlarged to form a *seminal vesicle* which lies toward the dorsal side. The vas deferens, near the junction of the middle and outer thirds of the cirrus pouch, becomes reduced in size, turns mediad and, running along the ventral wall of the pouch again swells out into a small spindle-shaped vesicle in

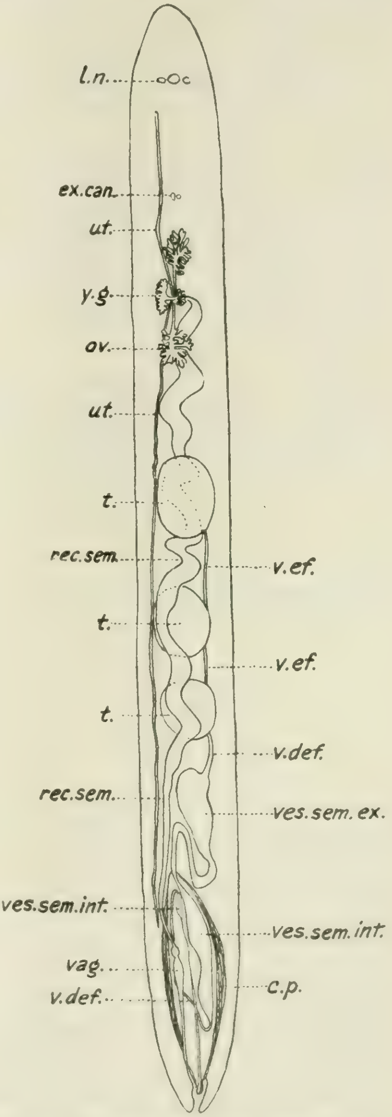
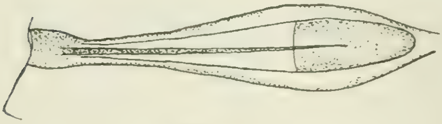


Fig. 117.—Transverse section of proglottid of *H. lanceolata*: *c. p.*, cirrus pouch; *ex. can.*, excretory canals; *l. n.*, lateral longitudinal nerves; *ov.*, ovary; *rec. sem.*, receptaculum seminis; *t.*, testis; *ut.*, uterus; *vag.*, vagina; *v. def.* vas deferens; *v. ef.*, vas efferens; *ves. sem. ex.*, vesicula seminalis externa; *ves. sem. int.*, vesicula seminalis interna; *y. g.*, yolk gland. Enlarged. (After Wolffhügel, 1900b, p. 51, fig. 2.)

the proximal portion of the latter. The vas deferens now runs laterad again and near the junction of the inner and middle thirds of the pouch is transformed into the *cirrus* which opens outwardly at the tip of the cirrus pouch through the common genital pore. The portion of the vas deferens within the cirrus pouch, including the cirrus, is supplied with longitudinal and circular muscle fibers of varying degrees of development in different portions. The cirrus (figs. 117, 121) is armed with spines and is often seen evaginated through the genital pore. The distal end of the cirrus pouch may also be extruded for some distance through the pore (fig. 120). The occurrence of a loop in the vas deferens, in its course within the cirrus pouch, as described for *Hymenolepis lanceolata*, has been demonstrated, also, in a number of other tapeworms, in *Hymenolepis fasciata* (Krabbe) by Feuereisen (1868a), in *Hymenolepis gracilis* by Wolffhügel (1900a), in *Hymenolepis megalops* by Ransom (1902), and apparently in *Hymenolepis sinuosa* by Kowalewski (1895).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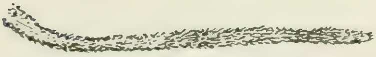
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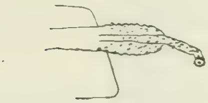
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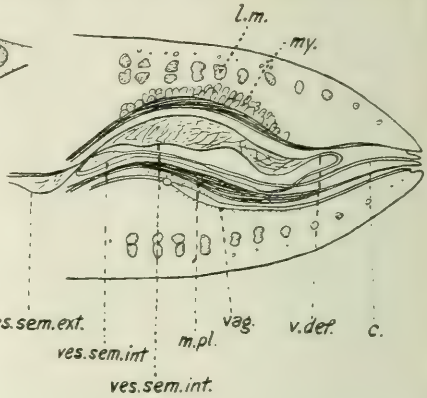

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FIG. 118.—Cirrus pouch and cirrus of *H. lanceolata*. Enlarged. (After Feuereisen, 1868a, pl. 10, fig. 9.)

FIG. 119.—Isolated cirrus of *H. lanceolata*. Enlarged. (After Mégnin, 1881, pl. 4, fig. 7.)

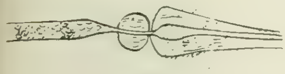
FIG. 120.—Extruded cirrus and tip of cirrus pouch of *H. lanceolata*. Enlarged. (After Feuereisen, 1868a, pl. 4, fig. 8.)

FIG. 121.—Transverse section of proglottid of *H. lanceolata*, showing the cirrus pouch and vagina: *c.*, cirrus; *l. m.*, longitudinal muscles; *m. pl.*, muscle plates of cirrus pouch; *my.*, myoblasts; *vag.*, vagina; *v. def.*, vas deferens; *ves. sem. ext.*, vesicula seminalis externa; *ves. sem. int.*, vesicula seminalis interna. Enlarged. (After Wolffhügel, 1900b, p. 52, fig. 3.)

Female organs. The *vagina* (*vag.*, figs. 115, 117, 121) begins at the genital pore as a tube about 7μ in diameter, lying ventral and somewhat anterior with respect to the middle line of the cirrus pouch, and courses along the ventral side of the latter. The outer two-thirds of the portion in relation with the cirrus pouch (fig. 122), according to Wolffhügel, is lined by thick cuticula covered with fine spines, and is supplied with an inner layer of circular muscle fibers and an outer layer of longitudinal fibers. During its course inward from the genital pore the vagina increases gradually in diameter (to about 20μ).

then becomes abruptly narrower, losing an outer layer of cells and its lining of thick cuticula; at the point of constriction the vagina is surrounded by a spherical bulb consisting of short thick muscle fibers, longitudinally directed with respect to the vagina (figs. 122, 123). Beyond the muscle bulb the vagina is prolonged as a thin walled tube, and sooner or later widens out into an elongated *seminal receptacle*, about 85μ in diameter. The receptacle (*rec. sem.*, figs. 115, 117) extends mediad on the anterior side of the two dextral testes, and on the posterior side of the sinistral testis, and continues past the median line into the sinistral third of the proglottis to empty into the oviduct.

The *ovary* (*ov.*, figs. 115, 117) consists of two lobes connected by a slender isthmus. The *oviduct* takes its origin from the middle of the isthmus (fig. 124); about midway between its origin and the point at which it is surrounded by the *shell gland*, it is joined by the seminal receptacle. The *yolk gland* (*y. g.*, figs. 117, 124) is ventrally situated with respect to the ovary and has a diameter equal to about one-third the length of the proglottis. The *yolk duct* (fig. 124) joins the oviduct in the *shell gland* (*s. g.*, fig. 124), a rounded body about $100\ \mu$ in diameter located dorsal of the isthmus of the ovary. From the shell gland the oviduct continues forward and ventrad to the *uterus* (*ut.*, figs. 117, 124). The latter at first is a thin canal, ventrally situated near the anterior boundary of the proglottis, extending transversely beyond the excretory canals on either side. In gravid segments the uterus becomes a large sac with outpocketings which push between the longitudinal muscle bundles and out against the cuticula, thus filling most of the segment.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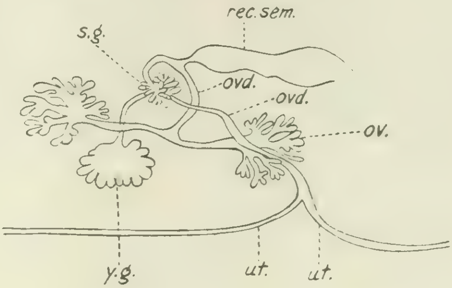

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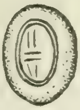
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Fig. 122.—Portion of the vagina of *H. lanceolata*. Longitudinal section. Enlarged. (After Wolffhügel, 1900b, p. 53, fig. 4.)

Fig. 123.—Transverse section of vagina of *H. lanceolata* through muscle bulb. Enlarged. (After Wolffhügel, 1900b, p. 53, fig. 5.)

Fig. 124.—Diagramatic representation of the female canals of *H. lanceolata*: *ov.*, ovary; *ovd.*, oviduct; *rec. sem.*, receptaculum seminis; *s. g.*, shell gland; *ut.*, uterus; *y. g.*, yoke gland. Enlarged. (After Wolffhügel, 1900b, p. 54, fig. 6.)

Fig. 125.—Egg of *H. lanceolata*. Enlarged. (After Railliet, 1886, p. 267, fig. 163B; also Railliet, 1893, p. 300, fig. 195B.)

Eggs.—The egg (fig. 125) is spherical or oval and possesses an outer and an inner membrane. The latter closely invests the embryo and is widely separated from the outer membrane. There is thus considerable similarity between the eggs of *Hymenolepis lanceolata* and *H. diminuta*. The *outer membrane* of the former, however, does not become thickened as in the case of the latter, but remains very thin, and the intervening substance between the two membranes is less conspicuous and does not ordinarily present the appearance of a third membrane as is usual in the latter instance. The *inner membrane* occasionally presents polar papillæ as in *H. diminuta* and *H. nana*. The egg measures, according to Railliet (1893), 50 by 35 μ, and the embryonal hooks, according to Krabbe (1869), 8 μ. According to my own measurements the outer membrane varies from 60 to 100 μ in diameter, the inner measures 30 by 25 μ to 40 by 25 μ, and the hooks from 12 to 15 μ.

DEVELOPMENT AND LIFE HISTORY.

Mrázek (1896, p. 11) mentions some cysticercoids which he found in various small crustaceans of the family Cyclopidæ. These cysticercoids agreed as to the form and size of the hooks with *H. lanceolata*, and Mrázek accordingly considered them the intermediate stage of the tapeworm under discussion. He gives no description or figures, merely remarking that the cysticercoids are almost exactly similar to those of *Tænia setigera*.

Dadai (1900a) found a large number of specimens of a cercocystis (figs. 126–130) in small crustacea, *Diaptomus spinosus* Dadai, collected from stagnant pools in Vadkert, Hungary, which he would identify with *Hymenolepis* (*Drepanidotænia*) *lanceolata* (Bloch).

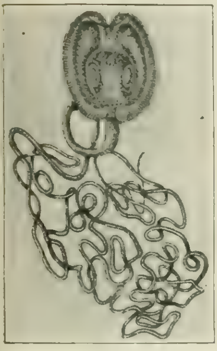
The cyst is more or less spherical with a remarkably thick wall, the circular and longitudinal muscle layers being remarkably well developed. A few calcareous corpuscles were seen in the inner layer of the parenchyma of the cyst wall. The cyst measured 0.23 to 0.28 mm. in length, and 0.18 to 0.23 mm. in diameter.

The head was occasionally seen extruded through the anterior opening of the cyst (fig. 128), but usually was found retracted and filling the cavity of the cyst almost entirely (figs. 126, 127). The rostellum was either retracted into the scolex or protruded. The number (8) and the form of the hooks (fig. 127) was the same as in *H. lanceolata*, but their size was very different, 55 to 60 μ, while in the latter they measure only 31 to 35 μ, which renders the correctness of Dadai's identification rather doubtful.

The caudal appendage is remarkable for its very great length. Its surface is very frequently marked by ring-like corrugations. It consists chiefly of granulated protoplasm and sometimes of masses of parenchyma cells; running lengthwise through its center is a characteristic thread-like structure, which consists of a dark, finely granular layer of protoplasm surrounding a still darker central fiber (fig. 127).

It has not been proved experimentally that the larvæ found by Mrázek or Dadai represent the intermediate stage of *Hymenolepis lanceolata;* but, upon the assumption that they or similar larvæ belong to the life-cycle, it may be presumed that infection occurs as follows:

The embryos of the tapeworm are distributed in stagnant pools by infected ducks or geese, and are ingested, whether before or after hatching is not known, by *Cyclops*, *Diaptomus*, or other small crustacea, in the body cavity of which the intermediate stage develops. The intermediate stage is introduced into the alimentary canal of some animal, normally a duck or a goose, by the drinking of water contain-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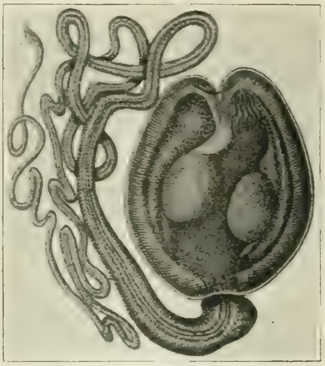
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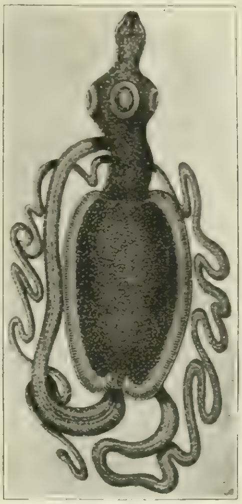
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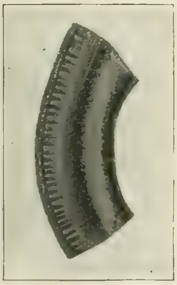
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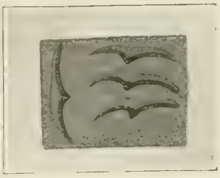
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Fig. 126.—Cercocystis of [?] *H. lanceolata* with scolex retracted. Enlarged. (After Dadai, 1900a, pl. 10, fig. 9.)

Fig. 127.—Cercocystis of [?] *H. lanceolata* with scolex retracted. Enlarged. (After Dadai, 1900a, pl. 10, fig. 7.)

Fig. 128.—Cercocystis of [?] *H. lanceolata* with scolex protruded. Enlarged. (After Dadai, 1900a, pl. 10, fig. 11.)

Fig. 129.—Section of wall of cercocystis of [?] *H. lanceolata*. Enlarged. (After Dadai, 1900a, pl. 10, fig. 12.)

Fig. 130.—Hooks of cercocystis of [?] *H. lanceolata*. Enlarged. (After Dadai, 1900a, pl. 10, fig. 8.)

ing infected crustacea, and the definitive stage may then be developed. Although certainly very unusual, it appears that development of the adult following the ingestion of the intermediate stage may occur also in the human intestine.

ABSTRACT OF CASE OF HYMENOLEPIS LANCEOLATA IN MAN.

Breslau, Germany, 1902	1 case.

This unique case has been reported by Zschokke (1902a, b), who received two tapeworms for determination which had been passed spontaneously, at two different times, by a 12-year-old boy at Breslau. The heads were lacking in both specimens, but a careful anatomical study left no doubt as to their identity with *Hymenolepis lanceolata* (Bloch).

COMPENDIUM OF THE THREE PARASITES, H. NANA, H. DIMINUTA, AND H. LANCEOLATA, ARRANGED ACCORDING TO THEIR HOSTS.

In the following compendium all the hosts reported for any of the three tapeworms discussed in this paper are included.

(*) Signifies that I have examined specimens of the parasite from the host in question.

(?) Signifies that the correctness of the determination is considered doubtful.

Class **MAMMALIA**—Mammals.

Order PRIMATES.

HOMO SAPIENS—Man.

* *Hymenolepis nana*	Intestine.
Hymenolepis nana	? Bladder (p. 56).
* *Hymenolepis diminuta*	Intestine.
Hymenolepis lanceolata	Intestine.

Order RODENTIA—Rodents.

MUS DECUMANUS[a]—Brown or Norway rat.

* *Hymenolepis nana*	Intestine.
* *Hymenolepis diminuta*	Intestine.

MUS RATTUS ALEXANDRINUS—Egyptian or roof rat.

Hymenolepis diminuta	Intestine.

MUS RATTUS—Black rat.

Hymenolepis nana	Intestine.
Hymenolepis diminuta	Intestine.

[a] The names used for the rodents in this list are those given by Trouessart, 1889–1898, Catalogus mammalium tam viventium quam fossilium. Nova editio (prima completa). 8°. Berlin.

MUS MUSCULUS—House mouse.

Hymenolepis nana .... Intestine.
Hymenolepis diminuta .... Intestine.

MUS MINUTUS—Dwarf field mouse.

Hymenolepis nana .... Intestine.

MUS SYLVATICUS—Wood, or field mouse.

Hymenolepis nana .... Intestine.

ELIOMYS QUERCINUS—Garden dormouse.

Hymenolepis nana .... Intestine.

RHIPIDOMYS PYRRHORHINUS.

Hymenolepis diminuta .... Intestine.

Class AVES—Birds.

ANAS BOSCHAS DOMESTICA—Tame duck.

Hymenolepis lanceolata .... Intestine.

ANAS OBSCURA—Black duck.

Hymenolepis lanceolata .... Intestine.

ANSER ANSER DOMESTICUS—Tame goose.

**Hymenolepis lanceolata* .... Intestine.

CAIRINA MOSCHATA—Muscovy duck.

Hymenolepis lanceolata .... Intestine.

ERISMATURA LEUCOCEPHALA—White-headed duck.

Hymenolepis lanceolata .... Intestine.

AYTHYA FERINA—Pochard.

Hymenolepis lanceolata .... Intestine.

AYTHYA NYROCA—African teal.

Hymenolepis lanceolata .... Intestine.

AYTHYA RUFINA—Red-crested pochard.

Hymenolepis lanceolata .... Intestine.

PHŒNICOPTERUS ROSEUS—Flamingo.

Hymenolepis lanceolata .... Intestine.

Branch ARTHROPODA Arthropods.

Class INSECTA—Insects.

ASOPIA FARINALIS—Meal moth.

Hymenolepis diminuta (larval stage) .... Abdominal cavity.

ANISOLABIS ANNULIPES—Earwig.

Hymenolepis diminuta (larval stage) .... Abdominal cavity.

ACIS SPINOSA—Beetle.

Hymenolepis diminuta (larval stage) .... Abdominal cavity.

SCAURUS STRIATUS—Beetle.

Hymenolepis diminuta (larval stage) .... Abdominal cavity.

Class **CRUSTACEA**—Crustaceans.

Order COPEPODA.

Family CYCLOPIDÆ.

Genera? species?

?*Hymenolepis lanceolata* (larval stage).

DIAPTOMUS SPINOSUS.

?*Hymenolepis lanceolata* (larval stage).

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(*) Indicates that the article so marked contains original observations concerning one or another of the above-named tapeworms.

The forms and abbreviations used are those employed in the Index-Catalogue of Medical and Veterinary Zoology, Bull. No. 39, Bureau of Animal Industry, United States Department of Agriculture, Washington [W^{a}., Library of the Department of Agriculture; W^{c}., Library of Congress; W^{m}., Library of the Surgeon-General's Office of the United States Army; W^{s}., Library of the Smithsonian Institution; Lib. Stiles, Library of Ch. Wardell Stiles, United States Public Health and Marine Hospital Service, Washington, D. C.].

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